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Basic Manufacturing Math

Basic Manufacturing Math is a non-credit contextualized math course designed to assist students in developing the necessary math skills to complete the manufacturing curriculum. At COCC, this non-credit, ABS-level course is taught in modules as a series of break-out sessions for students currently enrolled in the credit Manufacturing Technology program. The target population is first-term students in the program identified with very low math skills based on Accuplacer math scores.

Topic	Activity	Application
Introduction (Suggested time: three 45-minute sessions)	Symbols and Operations Order of Operations Problem Solving Process	Problems working with area
Fractions (Suggested time: six 45-minute sessions)	Understanding fractions, reducing fractions, equivalent fractions, add, subtract, multiply, divide Measurement Changing between fractions and decimals Unity fractions/conversions	Working with fractional tolerances; calculation of size of parts Sawing bar stock Reading fraction steel rules in different scales; converting decimals to specific fractional denominator
Decimals (Suggested time: five 45-minute sessions)	Reading, writing, rounding decimals Changing between decimals and fractions Addition, subtraction multiplication and division	Micrometers, Vernier caliper, determining dimensions Working with decimal rules Working with decimal tolerances Blueprint – Converting fractions to decimals on a print
Speed and Feeds (Suggested time: two 45-minute sessions)	Reading charts Balancing equations	Feeds and speeds Taper
Statistical Process Control (Suggested time: two 45-minute sessions)	Calculating mean and range Standard Deviation	Quality Control
Ratio and Direct Proportion (Suggested time: two 45-minute sessions)	Ratios – what they mean; how to read and write ratios Rates – what they mean and	Gear ratios RPM, IPR, IPM (examples)

	how to calculate Unit fractions/conversions Proportions	Ft/min to in/sec (example) Scales: actual size of drawings
Metric System (Suggested time: two 45-minute sessions)	Metric unit id/understanding of unit sizes	Conversion within the metric system Calculate metric weight of part based on weight of material in cubic inches
DMS and Decimal Degrees (Suggested time: one 45-minute session)	Conversion from decimal degrees to DMS Conversion of degrees, minutes, and seconds to decimal degrees	
Geometry Basics (Suggested time: five 45-minute sessions)	Polygons Types of Angles Circles Area Volume	Finding diameter, radius, and circumference Cylinder bore
Triangle Math (Suggested time: four 45-minute sessions)	Pythagorean Theorem Trigonometric Functions	Solving for missing side of right triangle Hole locations on bolt circles Sin Bar and Gage Block Height

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Basic Automotive Math Lesson Plan Outline

At COCC, this non-credit, ABS-level course is taught in modules as a series of break-out sessions for students currently enrolled in the credit Automotive Technology program. The target population is first-term students in the program identified with very low math skills based on Accuplacer math scores.

Lesson/Module Topics	Activities	Auto Applications
Introduction to Basic Automotive Mathematics	Symbols and Operations Order of Operations Problem Solving Process	Resistance formulas; Ohm's Law Problems working with area and volume
Decimals	Reading, writing, rounding decimals Addition, Subtraction, and estimation Multiplication and Division	Working with micrometers and dial indications; MPG; estimate and calculate repair costs; taper and out-of-round on cylinders; clearances; compression ratios; run out on brakes; convert watts to horsepower; ohm's law; series and parallel resistance
Fractions	Types of fractions; changing improper fractions between mixed numbers; reducing fractions; multiplying and dividing fractions	Reading a ruler; using drill chart; parallel resistance; thread pitch; tubing and hose size and length
Plane Geometry	Working with angles Area of circle	Protractors; alignment Hydraulics – force, pressure, and area DMS to Decimal degrees Camshaft timing
Metric System	Metric unit id/understanding of unit sizes	Conversion in Metric system; Metric conversion chart
Signed Number Operations	Adding and subtraction integers and fractions	Camber, caster, toe
Ratio and Proportions (direct)	Ratios Rates Unit fractions/conversions within English or Metric Systems or English to Metric/Metric to English measurements Percents – How to calculate	Aspect ratios; fuel to oil ratios; antifreeze to water; gear ratios (teeth to teeth only); compression ratios; Ring and pinion; mph, fps (examples) cm/in; gal/pt; miles/km; lbs to ounces (examples) Compression testing between cylinders; Percent of error
Proportions (indirect)	How to set up and why	Overall drive ratios; pulleys; speedometer calibration
3-dimensional geometry	Volume of right cylinder	Cylinder Volume, Compression ratios

Electrical		Ohm's Law; Series, Parallel, and series-parallel circuit id and formulas; PIER chart ; voltage drop

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Basic Geometry

Purpose of this unit is to introduce students to **basic geometric terms and formulas for common polygons** that will be used in the manufacturing industry. Also included in this module will be a discussion of **circle measurements**.

Student Objectives

- Understand basic geometric terms with plane geometry
- Express quantities in the correct form: linear, square, cubic
- Calculate area and volume of certain polygons
- Use a protractor to determine the size of angles
- Calculate circumference, diameter, radius and area of a circle

Topic	Activity	Notes
Importance of Vocabulary	Tell students that understanding vocabulary and common abbreviations will be of great importance in working with angles and circles and their formulas. Tell students that throughout this module, there will be reference to new vocabulary and abbreviations for use in formulas. Remind students to write down new terms for this new "language".	The main focus for this unit will be on angular and circular measurements as they apply to manufacturing applications. Much of this vocabulary will be new for students. Encourage students to keep a separate space in their notes to keep new vocabulary words
Types of Measurement	Introduce • Linear • Area	Many students do not understand the different types of measurements. You could introduce this here.

	• Volume Show students a metal object that has length, width, and height. • Explain that the distance around the outside of the object is a linear measurement. Tell students that this type of measurement is given in straight units such as inches, feet, centimeters, etc. • Explain that the actual sides of the object would be measured as area. For example if you needed to coat a particular part, you would need to know the area of the part. Tell students that this type of measurement is given in square units. Show students the different ways it can be written. • Explain that the volume is the capacity of or space taken up by the object and it is measured in cubic units. For example, if you were making a tank to hold a particular liquid, you would need to know the capacity the shape would hold, which would be given in cubic units. Tell students that this type of measurement is given in cubic units. Show students the different ways it can be written.	
Common Polygons	Explain Polygons to students. Go over the following vocabulary • Angles • Vertex • Sides • Height • Base • Length • Width • Parallel • Perpendicular	Make sure students take notes on this information.

	Draw the following shapes on the board and go over the vocabulary associated with each shape. • Triangle • Square • Rectangle • Parallelogram • Trapezoid Show students examples of where they might see these shapes and why certain calculations would be necessary. Introduce students to formulas for perimeter, area, and volume for shapes that are important for your program and application.	Showing students these shapes and giving the vocabulary is a lot to absorb if students are at a low math level. Depending on student level, you may want to approach the formulas one at a time so you don't lose the students attention. Practice Problems can be found in: *Practical Problems in Mathematics for Manufacturing*, pp. 82-88 and 95-97
Working with Angles	Types of angles based on a circle which is 360^0 • Acute (less than 90^0) • Right (a 90^0 angle) • Obtuse (more than 90^0 and less than 180^0) • Straight angle (180^0) **Protractors** Using an overhead or document camera, demonstrate how to use a protractor to measure angles, being sure to include measurements from the left and right side of the protractor. Create a student worksheet and have them practice measuring and/or drawing angles. Move around the room checking for correct usage and making corrections where necessary.	Draw examples of angles on the board or use an Overhead transparency or document camera to illustrate. Protractors for each student Handout for students to practice measuring angles This activity will give students a good opportunity to understand basic degree measurements when working with bevel protractor in layout. Bring examples to class for students to see. Practice Problems: *Mathematics for the Trades*, pp. 496-499

	If students have a good grasp of protractor use and basic types of angles, move on to explaining complementary and supplementary angles. **Complementary Angles** – these are angles that add up together to equal 90^0. The angles do not have to be next to each other, but they do have to add up to 90^0. Show students a few examples of complementary angles on the board. **Supplementary Angles** – these are angles that add up together to equal 180^0. The angles do not have to be next to each other, but they do have to add up to 180^0. Show students a few examples of supplementary angles on the board. Tell students that this information will be important when working with designs and layout of work.	
Parts of the Circle	Define a circle and its parts. Explain relationships between Circumference, diameter, and radius. Pi activity below. • **Center Point** • **Circumference (C)………………………** $C = \pi d$ • **Diameter (d)………………………………**$d = 2r$ • **Radius (r)……………………………………**$r = \frac{d}{2}$ • **Pi π ……………………………………………3.1416** • **Area (A)………………………………………**$A = \pi r^2$	Make sure students understand definitions for all of the highlighted words in this module. Draw relationships on the board. If this is the first time that students have worked with formulas, don't be surprised if students don't "get it" right away. Be

	If time allows have students use string and a ruler to measure the circumference and diameter of three circular objects like a CD, a jar lid, piston sleeve or you can have them go into the shop and find objects to measure. Tell students not to draw the string to tight. Make a chart on the board and have students record their linear measurements for each object. (see chart below) When all students have recorded at least two items, have them all look for similarities between the circumference and the diameter. (Circumference should be about 3 times as large as the diameter. Tell students this relationship between the circumference and the diameter of a circle is Pi, and it is the same for all circular objects.	patient and take time to help students understand formula variables and how to evaluate them. For more detailed description of circle parts see *Mathematics for Machine Technology*, Unit 49 This is a very basic math activity; although a little time consuming, it will help with students' deeper understanding of the concept of Pi.

Item	Circumference	Diameter

	Explain that Pi π, will be used in many of the formulas working with circles. Pi is a **constant**, meaning its value never changes. Example: Model the following problem using the problem solving process. A **cylinder bore** is 3.750". What is the circumference of the cylinder? • Cylinder bore is 3.750" (bore is diameter) • Looking for circumference • Formula is $C = \pi d$ • Evaluate formula (substitute known values) • Circumference is about 3 times larger than diameter $C = \pi d$ $C = 3.1416 * 3.750$ $C = 11.781''$ • This makes sense because 11.781 is approximately 3 times larger than 3.750 • Solved question • Units labeled.	Students can use Pi key on their calculator or have them use 3.1416, Be sure to use the problems solving process with these problems – • Read and understand the problem <u>including all instructions</u> • Identify important information that is given and make note of it • Identify the exact question(s) – write it(them) down • Identify other information that you might need such as a specific formula or conversion factor • Develop a plan to solve the problem and write it down • Estimate an answer • Solve the problem • Check Did you solve the question you identified? Does your answer make sense? Did you label your units? If desired, students can practice with simple circle problems; however, it might work best to move directly to application at this point. Practice problems:

	AREA is measured in square units. Up until now we have only worked with linear measurement. Be sure that students understand the difference between linear and square units. Show them how to make unit notation. (in^2) Example: Find the area of the top of a cylinder with a diameter of 3.250" • Diameter of top of cylinder is 3.250" • Looking for Area • Formula is $A = \pi r^2$ or $A = 0.7854d^2$ • Evaluate formula (substitute know values) $A = 0.7854 * d^2$ $A = 0.7854 * 3.250^2$ $A = 8.2957875\, in^2$ $A \approx 8.296\, in^2$ • Solved question • Units labeled **VOLUME is measured in cubic units.** PREP BEFORE CLASS	*Practical Problems in Mathematics for Manufacturing,* pp. 89-90 Volume (cubic measurement) is discussed in another module. Most manufacturing books will use $A = 0.7854d^2$ **; however, A =** πr^2 **will work as well** For students with poor spatial skills, this demonstration will help them see how the formula for a right cylinder is simply a

	Before class, take a tube like a paper towel holder, cut it in half from top to bottom. Make caps to fit on the top and bottom of the object. Tape the tube back together. Show students the cylinder you have created. Tell students that you need to find out what the cylinder will hold. Deconstruct the cylinder showing students that the cylinder itself is really a rectangle. • The length of the top and bottom edge of the cylinder is the same as the circumference of the circle. • The height is the measurement from top to bottom. • The caps represent the top and bottom (area) of the cylinder. Show students the formula to find the volume of the cylinder. $\boldsymbol{Volume = .7854d^2h}$ <u>or</u> $\boldsymbol{V = \pi r^2 h}$ Show students how to break down the formula and what all of the variables mean. Example: Find the volume of a cylindrical part with a diameter of 2 cm and a height of 6 cm. Use $\boldsymbol{V = \pi r^2 h}$ Tell students if they do not have a picture, it is a good idea to sketch the problem on their paper. Show students how to evaluate the problem and solve it. Remind students that radius is half the diameter.	combination of area of a circle and the height. Practice Problems can be found in: *Practical Problems in Mathematics for Manufacturing*, pp. 98-100 *Mathematics for Machine Technology*, pp. 387-391 *Mathematics for the Trades*, Chapter 9

	Show students examples of different **Prisms** and show them how to calculate volumes	

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DMS and Decimal Degrees

The purpose of this unit is to introduce students to conversion between DMS and decimal degrees that students will need in the manufacturing shop to change between these two angle formats.

<table>
<tr><td colspan="3">Student Objectives
• Convert Degrees, Minutes, Seconds to Decimal degrees
• Convert Decimal degrees to Degrees, Minutes and Seconds</td></tr>
<tr><td>Topic</td><td>Activity</td><td>Notes</td></tr>
<tr><td>DMS and Decimal Degrees</td><td>Explain to students when they will see DMS and when they will likely see Decimal degrees

Tell students why this is necessary in the manufacturing industry</td><td></td></tr>
<tr><td>Conversion from Decimal Degrees to DMS</td><td>Tell students there will be times they will need to convert between decimal degrees and degrees, minutes, and seconds.

Give students the following information.

60 minutes = 1 degree abbreviated, 60’ = 1^0
60 seconds = 1 minute abbreviated, 60” = 1’

Convert 78.4^0 to degrees and minutes.</td><td></td></tr>
</table>

	Step 1 Write the angle measurement as a whole number and a decimal fraction $17.4° = 17° + .4°$ Step 2 Use unity fraction to covert $.4^0$ to minutes. $17° + \left(\frac{.4}{1} \times \frac{60'}{1}\right)$ $17°24'$ Convert 192.5690^0 to degrees, minutes, and seconds Step 1 Write the angle measurement as a whole number and a decimal fraction $192° + .5690°$ Step 2 Use unity fraction to covert $.5690^0$ to minutes $192 + \frac{.5690}{1} X \frac{60'}{1°}$	

	$192 + 34.14'$ Step 3 Use unity fraction to change .14'to seconds $192° \, 34' + \frac{.14}{1} \times \frac{60"}{1'}$ $192° \, 34' \, 8"$	Practice Problems: *Mathematics for Machine Technology*, p. 288, problems 4-23
Conversion of Degrees, Minutes and Seconds to Decimal Degrees	Show students how to move from degrees and minutes to decimal form. Convert 94^0 3' Step 1 Write the angle as a sum of degrees and minutes $94° + 3'$ Step 2 Use a unity fraction to convert minutes to degrees. $94° + \left(\frac{3'}{1} \times \frac{1°}{60'}\right)$ $94.05°$ Convert 27^0 18' 21" to decimal degrees Step 1 Write the angle as a sum of degrees, minutes, and seconds	

	$27° + 18' + 21"$ Step 2 $\frac{21"}{60} = .35'$ Step 3 Add .35' to 18' $.35' + 18' = 18.35'$ Step 4 Divide 18.35' by 60 $\frac{18.35'}{60} = .3058\overline{3}$ Step 5 Add this to the total degrees $27.3058°$	Practice Problems: *Mathematics for Machine Technology*, p. 288, problems 24-41

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Metric System

The purpose of this unit is to introduce students to the **metric system**. A focus on English/Metric conversion as well as using metric measuring instruments will be included.

Student Objectives

- Learn basics of the metric system
- Understand metric units for manufacturing trade
- Convert within the metric system
- Convert between metric and standard system
- Using metric micrometers

Topic	Activity	Notes
A Comparative Look	Give common examples of liter, meter, and gram to real life items with which students can relate. Use paper clip to show centimeter, millimeter and gram. • Width of paper clip is about a centimeter • Width of paper clip wire is about a millimeter • Weight (mass) of paper clip is about a gram It is nice to have a meter stick and a yardstick so students can see the difference. For liquid measure be sure to bring a quart and liter bottle so you can fill quart and pour into the liter container.	

	Tell students that in the metric system the most common base units are: • Meter for length (m) • Gram for weight/mass (g) • Liter for liquid measurement (L)	There are other metric measurements that are common to the trades: • Temperature measured in Celsius • Bending movement/ torque/moment of force measured in newton meter (N·m) • Pressure/vacuum measured in kilopascal (kPa) • Velocity measured in kilometers per hour (km/h) • Force, thrust drag measured in newton (N) • Power measured in (W)
Review of Decimal Place System Metric Prefixes	Write place values on the board for decimal system including whole numbers from at least 1000 to 0.001. Review place values with students having them say the names of each place correctly Tell students that the metric system is not much different. Change “ones” place to “base unit” *(At this point you may want to expand the numbers to 1,000,000 and 0.000 001 on the chart you create on the board making sure you leave spaces for all of the numbers that come in between these)* Go over Metric prefixes and label on board under the English measurements.	Review of place values is important. Use OPABS Math I lessons 2-5 for additional handouts on this metric section. Manufacturing students do not need extensive hours of training on the metric system; however, it is important for them to understand how it is based on multiples of 10, uses prefixes, and the base units. Hand out a *blank metric staircase chart* so students will be able to follow along and add these prefixes as you go over them. You will have to add additional steps to the materials

	Tell students these are the prefixes with which they will need to be familiar in the manufacturing industry. Although hecto, deca, and deci are not used as often, they need to know the place value. **1000 – kilo (k)** 100 – hecto (h) 10 – deca- (da) **1 - Base Unit** 0.1 – deci (d) **0.01 – centi (c)** **0.001 – milli (m)** A good way to remember the names is by use of a mnemonic like: **K**ing **H**enry **D**ied **B**y **D**rinking **C**hocolate **M**ilk Tell students that unlike the English system of having to know things like 5280 feet = 1 mile, the metric system simply moves the decimal point to convert from base unit meter to kilometers. Demonstrate changing base unit of meter to kilometer by moving decimal points on step chart. Demonstrate how to move the decimal to convert different measurements like: • 5 meters to centimeters • 22 milligrams to grams	from OPABS Math I. Students can also make up their own – this is just a suggestion.

Basics of the Metric System	Tell students that the official name for the metric system is the International System of Units. They will often see it referred to as "SI" metrics Unit symbols are not abbreviations and don't need a period afterwards Symbols are the same for singular and plural (1 cm or 15 cm) Numbers of 5 or more digits are written in groups of 3 with a space instead of a comma 7 325 not 7325 or 7,325 56 452 not 56,452 23 428 173.87 229 not 23,428,173.87229 Always place a zero to the left of the decimal point if there is no whole number in the measurement. Area and volume units are written using exponents: 6 cm^2 not 6 sq cm 42 cm^3 not 42 cu cm	
Conversion between Standard and Metric Units	Tell students there are always tables that show most of the conversion factors and what operation to follow, but sometimes you simply have to understand relationships to make conversions. The more practice, the better you will become at this technical skill. A simple conversion chart can be found in *Mathematics for Machine Technology*, p.132.	Many students will prefer to use the conversion tables, but they should be encouraged to use the unity fraction method. Students who take a technical math course

	Unity fraction method: Determine the relationship between quantities and create a unity fraction for your problem. Step 1: Write the unit to be changed as a number with a denominator of 1 Step 2- Set up unity fraction so that unwanted units will cancel out. Step 3 – Cross cancel, multiply, and label answer Convert 362 cm to inches $\frac{1\ in}{2.54\ cm}\ or\ \frac{2.54\ cm}{1\ in}$ Step 1 $\frac{362\ cm}{1}$ Step 2 $\frac{362\ cm}{1} * \frac{1\ in}{2.54\ cm}$ Step 3 $\frac{362\ \cancel{cm}}{1} * \frac{1\ in}{2.54\ \cancel{cm}} = \frac{362 * 1\ in}{2.54} = \frac{142.5\ in}{1}\ or\ 142.5\ in$	like Math 85 at COCC will need to understand this process. If you have already practiced this process with students, have them try these problem on their own. If this is new information, be sure to work with students, walk around and check for understanding.

	<u>Guided practice</u> Convert the following: 1. 52 kg to lb. 2. 11.6 miles to km 3. 23 cm to in. Ask students how they would convert 16.2 km/L to mpg. Record answers Show students there are two ways to do this. One: Convert km to miles and then convert L to gallon $\frac{16.2\ km}{1} * \frac{0.62137\ mi}{1\ km}$ $\frac{16.2\ \cancel{km}}{1} * \frac{0.621\ 37\ mi}{1\ \cancel{km}}$ $\frac{16.2}{1} * \frac{0.621037\ mi}{1}$ $\frac{16.2 * 0.621\ 37\ mi}{1}$ 10.066194 Two: Change Liters to gallons:	

$$\frac{10.066194\ mi}{1\ L} \times \frac{1L}{0.2642\ gal}$$

$$\frac{10.066194\ mi}{\cancel{1\ L}} \times \frac{\cancel{1L}}{0.2642\ gal}$$

$$\frac{10.066194\ mi}{0.2642\ gal}$$

$$38.10065859\ or\ 38.1\ mpg$$

Next show students how to do this by setting up one problem. Tell students to be careful that all units cancel out correctly.

$$\frac{16.2\ km}{1\ L} \times \frac{0.62137\ mi}{1\ km} \times \frac{1L}{0.2642\ gal}$$

$$\frac{16.2\ \cancel{km}}{1\ \cancel{L}} \times \frac{0.62137\ mi}{1\ \cancel{km}} \times \frac{1\cancel{L}}{0.2642\ gal}$$

$$\frac{16.2 \times .62137\ mi \times 1}{1 \times 1 \times 0.2642\ gal}$$

$$\frac{10.066194\ mi}{0.2642\ gal} = \frac{38.10065859\ mi}{1\ gal}$$

$$38.1\ mpg$$

Give students plenty of practice with this. Encourage them to use the second method with only one step. Once they get lots of practice, they will begin to see that it is actually less complicated than the two step method; however, either method will work.

If students are having trouble, do some more examples on the board or you can move directly to guided practice.

Be sure to move around the room to answer questions and check for understanding.

Practice Problems:
Mathematics for Machine Technology, pp. 135-136

	Guided practice: Convert the following. Tell students if they do not know the unity fraction where to find the information. 1. 21.65 in to cm 2. 0.080 meters to inches 3. 9.7 km/L to mpg 4. 43.8 mpg to km/L	
Measurement	Metric Micrometers Show students: Parts of micrometer Tell students about the different measurements and show them to how to calculate. There are two scales on the sleeve. The top marks indicate whole millimeters The bottom marks on the sleeve indicate 0.5 mm Each mark on the thimble indicates 0.1 mm Metric Vernier Calipers Show students parts of caliper Show students how to read metric scale Extended Practice Different materials or parts should also be available for students to measure in the classroom to get used to the *feel* they need for proper measurement.	Although many students don't ask for metric mikes, it is a good idea that they understand how to read them. Some shops may require the use of metric instruments instead of converting to English. Note to Instructor: before you show students how to read micrometer, be sure that they understand decimal place values Practice Problems: *Practical Problems in Mathematics for Manufacturing*, pp. 61-64, selected problems Practice Problems: *Practical Problems in Mathematics for Manufacturing*, pp. 64-65, selected problems

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Ratios and Direct Proportions

Purpose of this unit is to work with ratio and proportions as it relates to the manufacturing. A basic understanding of how fractions and decimals work would be helpful with this unit.

Student Objectives

- Understand and read ratios
- Use rates to express an idea
- Reduce ratios
- Solve direct and indirect proportions

Topic	Activity	Notes
What Is a Ratio?	For a warm up, ask students where they see ratios in their everyday life. If they need prodding, remind students that ratios are the comparison **of two like units**. (Responses could include things like money to money, weight to weight) Review ways that ratios can be written: • 40 to 17 • 40:17 • $\frac{40}{17}$ Remind students that they are all “said” the same way: • 40 to 17 Tell students that ratios are a comparison of two numbers by	Students may come up with ideas that are actually rates (which compare two unlike units) such as miles to gallons. Acknowledge that they are a type of ratio but will be discussed later. Students may note that a ratio looks like a fraction. Tell students that fractions are a type of ratio that compare a part to a whole, but ratios are a comparison of part to part, whole to whole, or part to whole.

	division. Tell students that ratios are always written the way the two amounts are compared. If you are comparing 100 turns of a large pulley to 200 turns of smaller pulley, the ratio would be written: $\frac{Large\ Pulley}{Small\ Pulley}\ \frac{100}{200}$ This tells us that for every 100 turns of the large pulley the small pulley turns 200 times. Tell students that although ratios do not include units, while learning, it is not a bad idea to label as shown above. This ratio would not be written as $\frac{200}{100}$ because you would then be comparing the small pulley to the large pulley. **Simplifying Ratios** Remind students that ratios are always reduced to lowest terms. Using the example above, show students how to reduce the ratio.	This is a good time to remind students that although order does not matter with multiplication, it does matter with division. It is a good idea to first show the ratio in terms of complete amounts. For students who are less familiar with ratios, this will make more sense. Once they understand this concept, reducing will make more sense.

	$\frac{\lg pulley}{sm\ pulley} = \frac{100}{200} = \frac{100 * 1}{100 * 2} = \frac{\cancel{100} * 1}{\cancel{100} * 2} = \frac{1}{2}\ or\ 1:2$ This tells us that for 1 turn of the large pulley there are 2 turns of the small pulley. Model another ratio like **gear teeth to gear teeth**. Problem 1: A large gear has 36 teeth and a small gear has 9 teeth. Compare the teeth on the larger gear to the teeth on the smaller gear. $\frac{\lg gear}{sm\ gear} = \frac{36}{9} = \frac{9x4}{9x1} = \frac{\cancel{9}x4}{\cancel{9}x1} = \frac{4}{1}$ Now ask students ***what the ratio of 4:1 means***. Problem 2: Use the information above from Problem 1, but now compare the small gear to the larger gear. Ask students what the ratio of teeth to teeth would be. Ask students what this means. Ratios can also be a comparison of two fractions.	

	For example: Simplify $\frac{\frac{1}{2}}{\frac{2}{3}}$ $\frac{\frac{1}{2}}{\frac{2}{3}} = \frac{1}{2} \div \frac{2}{3} = \frac{1}{2} * \frac{3}{4} = \frac{3}{4}\ or\ 3:4$ Ask students to simplify $1\frac{7}{12}:\frac{11}{12}$ 19:11 Show students how to simplify ratios as decimals: 1.2:3.6 $\frac{1.2 * 10}{3.6 * 10} = \frac{12}{36} = \frac{1}{3}\ or\ 1:3$ Sometimes ratios can be a comparison of a whole number and a decimal. $\frac{2}{1.75} = \frac{2 * 100}{1.75 * 100} = \frac{200}{175} = \frac{8}{7}\ or\ 8:7$ If the ratio compares a fraction to a decimal, make them	

	common units and simplify. $\frac{1}{2}$ to 0.75 Since $\frac{1}{2}$ is the same as .5 $\frac{0.5}{0.75} = \frac{0.5*100}{0.75*100} = \frac{50}{75} = \frac{2}{3}\ or\ 2:3$ Show students 0.65 to $\frac{4}{5}$ Since 0.65 = $\frac{65}{100}$ $\frac{65}{100} \div \frac{4}{5} = \frac{65}{100} * \frac{5}{4} = \frac{13}{16}\ or\ 13:16$ Finally tell students that ratios are often expressed as a comparison to one. Divide both the numerator and the denominator by the numerator. The answer is usually rounded to the nearest tenth. For example: 9:2 = x:1 $\frac{9 \div 2}{2 \div 2} = \frac{4.5}{1}\ or\ 4.5:1$	

	Guided Practice: Simplify the following to the two smallest whole numbers: 1. 12:6 2. 100:100 3. $\frac{1}{3}:\frac{1}{2}$ 4. 2.4:.5 5. 2.5:$1\frac{1}{2}$ Find the ratio of the largest quantity to the smallest quantity. Remember to change quantities to *like units* if necessary. 6. \$3.00 to \$0.75 7. $\frac{1}{2}$ yd to 4 “ 8. 3 cm to 0.4 cm 9. $\frac{1}{4}$ hour to 20 min	Students should be encouraged to practice use of unity fractions if necessary.
Rates	**Rates** are ratios that compare **two different units**. Ask students if they have examples. Remind students that rates are a comparison of unlike units. Rates are most often expressed as a whole number or decimals to one.	Remind students that “per” means to divide

	Examples: 60 revolutions in one minute or 60 RPM = 60:1 (60/1) 47.5 miles to one gallon of gas or 47.5 MPG= 47.5:1 (47.5/1) Guided Practice: Express the following rates in *simplest* form. 1. 150 miles in 3 hours 2. 80 revolutions in 4 seconds 3. 5 welding rods for $20 4. 15 safety glasses for 15 technicians 5. 22 kilograms per square meter	
Ratios as Decimals and Percents	On a quality control check, Mike found that 18 out of 24 parts were within specification. Find the percent of acceptable parts out of the total. Tell students this can be answered with a ratio. $\frac{correct}{total}\ \frac{18}{24}=\frac{6*3}{6*4}=\frac{\cancel{6}*3}{\cancel{6}*4}=\frac{3}{4}=.75=75\%$ Guided Practice Express ratios as percents 1. 4:5 2. 4:2 3. 16:20 4. 5:17 Express a percent number as a ratio Examples:	This section is written with the assumption that students have a basic knowledge of changing between fractions, decimals, and percents.

	$20\% = \frac{20}{100} = \frac{1}{5}$ or 1: 5 $\frac{2}{3}\% = \frac{2/3}{100} = \frac{2}{3} \div \frac{100}{1} = \frac{2}{3} * \frac{1}{100} = \frac{2}{300}$ or 2: 300 Guided Practice Express the following percents as simplified ratios 1. 20% 2. 9% 3. 0.4% 4. 100% Changing decimals to ratios Examples: $0.25 = \frac{25}{100} = \frac{25 * 1}{25 * 4} = \frac{\cancel{25} * 1}{\cancel{25} * 4} = \frac{1}{4}$ or 1: 4 $0.375 = \frac{375}{1000} = \frac{3}{8}$ or 3: 8 Guided Practice Change the following decimals to ratios in lowest terms 1. 0.75 2. $0.62\frac{1}{2}$ 3. 1.00 4. 0.27	
Ratio Applications	**Gear ratios** are given comparing the driven gear to the drive gear.	Once students have a good understanding of

	Two gears are in mesh. If the driving gear has 24 teeth and the driven gear has 12 teeth, then the gear ratio would be 12:24 or 1:2 **Other places students might see ratios**: Comparing diameters Comparing sides and/or angles of triangles Working with scale drawings Working with mixtures Trigonometry	ratio, their main application with be setting up and solving proportion problems Addition problems can be found: *Mathematics for Machine Technology*, pp. 94-96. *Practical Problems in Mathematics for Manufacturing*, pp.116-118
Proportions	**Direct Proportions** are equal ratios. As the parts of one ratio get larger, the parts of the other ratio get larger at an equal rate. On the other hand as parts of one ratio get smaller the parts of the other ratio get smaller at an equal rate. EX: Machine oil is on sale for $6 for 2 quarts. We can write this as a ratio of $\frac{\$}{quarts} = \frac{6}{2}$ We can multiply this ratio by $\frac{2}{2}$ So 12 cans would cost how much? $\frac{\$}{cans} = \frac{6*2}{2*2} = \frac{12}{x}$	*If students don't understand proportions and what they mean, it is a good idea to stop and make sure they understand the concept,* ***before moving on to cross multiply and divide.***

	$12 for four cans of oil; $18 dollars for 6 cans of oil and so on. How much would one can cost? With a direct proportion, as the number of cans increases the cost increases proportionally. Or as then number of cans decreases the cost reduces proportionally. Set up your proportion. • Determine if the relationship if a direct proportion. • Identify the two quantities you are going to compare and write them as a ratio. • Write a ratio comparing the two quantities • Next write the ratio of the one known quantity and use X for the unknown. • Cross multiply your two knowns and divide by the last known to solve for X **Working with rates in a proportion** **Scale drawings** like those found on maps are another good example of direct proportion. Scales on maps are given as	*After students set up the two ratios, it is best if they can first identify the factor by which both numbers are multiplied. Once students understand this concept the instructor can advance to the cross multiply and divide method.* *Be sure students understand "knowns"* *Instructors may want to show student how to do this with extremes and means; however, this curriculum will use the cross multiply method.*

	ratios such as 1 inch: 12 miles. Tell students a good way to remember this is "DO" which stands for Drawing to Object. On a certain map with a scale of 1:12, Bend is about 2 inches from Redmond. About how far in real miles in Bend to Redmond? $\frac{D}{O} = \frac{1}{12} = \frac{2}{X}$ $(12 * 2) \div 1 = 24$ It is approximately **24 miles** from Bend to Redmond Ask students to think about the relationship between **<u>time and distance traveled.</u>** Have students write their own problem and see if other students can solve it. **Other places students might see proportions**: Changing between degrees and minutes	*If student knowledge is low and time allows, bring in different examples of maps for this activity. USA, state, county, city, and Forest Service maps are all good examples. These will also be useful if you are planning any type of graphing activity during your course.* Be sure to show students that there are different ways to set up proportions. When using rates this can be done the way it was shown above or keeping with the two different amounts being compared in one ratio. Additional Practice can be found: *Mathematics for Machine Technology*, pp. 96-99 *Practical Problems in Mathematics for*

	Determining Taper Solving Similar Triangles Percent Problems Right Angle Trigonometry	*Manufacturing*, pp. 119-123
Percent Problems	Tell students that percent problems can be solved using a proportion. Show student: $\frac{Part}{Base} = \frac{Rate}{100}$ Explain algorithm and its parts. Give students a few basic number problems to solve using this method. 1. What is 40% of 75? 2. 96% of 220 is what number? 3. 4 is what percent of 32? Application • Percent and/or number of rejected or scraped parts • Percent of a solution • Percent of tolerance • Power supplied or percent of efficiency • Percent of increase/decrease like purchase price, cooling length or expansion	If students do not have a good understanding of working with percent numbers, instructors may have to go back and teach: • What is meant by percent • How to change between percent, decimals, and fractions • How to identify base, rate, and portion (part) • How to solve short form questions such as 'What is 15% of 65?' or '25% of 60 is what number?' Additional Examples and Practice can be found in: *Mathematics for Machine Technology*, pp. 118-121 *Practical Problems in Machine Technology*, pp. 109-111 *Mathematics for the Trades*, pp. 253-258, selected problems

Inverse or Indirect Proportions	Review what is meant by a direct proportion Inverse or indirect proportions work a little differently. As one gets larger, the other gets smaller; as one goes faster, the other gets slower. A good example of this is the inverse relationship with gears and torque. As the size of the gear increases, the slower it turns. However, torque or force is the inverse of this. If this set of gears has a ratio of 1:2, it means that the larger gear would turn slower, but would have a twice the torque or force of the smaller gear. As speed is reduced, torque is increased. Tell students that since the relationships are inverse, so is the setup of the proportion. It will be *similar to* the difference between multiplying and dividing fractions. **Gear teeth and RPM relationship** Let go back to the gears and rpm. We have already established that the relationship is inverse – larger gear turns slower than smaller gear when the gears are in mesh. 1. We have a 40-tooth gear in mesh with a 10-tooth gear. The 10-tooth gear turns at 450 rpm. How fast would the 40-tooth gear turn? Tell student to set up the first ratio in fractional form.	*Although not as common an application as direct proportions, it is important for students to understand the concept on how to solve indirect proportions* For an example, you could have students attempt to solve this problem using the proportion form they have already used. If set up as a direct proportion they might get an answer of 1800 rpm for the larger gear. This gives a good talking point on how could the larger gear possibly turn that much faster than the smaller gear turning at 450 rpm.

	$\frac{TEETH}{teeth} = \frac{10}{40}$ Since the relationship is inverse, in our next ratio the numerator of the first ratio, must correspond to the denominator of the second ratio. Our second ratio be $\frac{rpm}{RPM} = \frac{X}{450}$ So our problem would look like: $\frac{10}{40} = \frac{X}{450}$ Now solve the problem as you would a proportion. $(10 * 450) \div 40$ 2. A 42-tooth gear is in mesh with a smaller gear mounted on a motor shaft. If the 42-tooth gear is turning at 425 rpm and the motor shaft is turning at <u>*about*</u> 1450 rpm, how many teeth are on the smaller gear? $\frac{42}{X} = \frac{1450}{425}$	Try not to use the word “flip” here. It is better for students to understand the correct terminology so they better understand the relationship.

	Pulley diameter works the same way as the teeth to rpm relationship since the relationship is also an inverse. If two pulleys are connected by a belt, the smaller pulley will increase the rpm or the larger pulley will slow down the rpm. 1. A 7-inch pulley is connected by a belt to a 3-inch pulley. The larger pulley turning at 750 rpm, is turning the smaller pulley. How fast is the smaller pulley turning? $\frac{7}{3} = \frac{X}{750}$	Additional Practice can be found: *Mathematics for Machine Technology*, p. 105 Practical Problems in Machine Technology, pp. 124-127

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Signed Numbers

The purpose of this module is to give students an introduction to integers and signed number operations as it relates to areas like chassis alignment. Degrees and Minutes are also discussed.

Student Objectives

- Add and subtract positive and negative integers
- Add and subtract signed decimals and fractions
- Change between Degrees/ Minutes and Decimal Degrees
- Calculate camber, caster, toe measurements

Topic	Activity	Notes
Adding Signed Numbers	Using a short number line show students where integers fall from +10 to -10 (or larger if desired) • A number on the number line is greater than any number to its left. • A number on the number line is less than any number to its right. Show students the +/- signs working with signed numbers. Ask students which is larger: -7 or -5 8 or -3 -2 or -5 Use the symbols < “less than”, > “greater than”, = “equal to”	For beginning students, work with a number line is essential when working with signed numbers. Rules will get messy for students if they cannot see and understand the process first

	-9_____-2 +3______-5 -1______+1 12_____-3 5_______+5 -1______-2 Show students an example of temperature change from -7^0 in the morning to 14^0 in the afternoon. Use the number line to show the change. In the problem above to find the difference in temperature between -7^0 and 14^0, add the 7 to both numbers. $-7° + +7 = 0°$ $14° + 7 = 21°\ temperature\ change$ Explain absolute value using number line, reminding students that absolute value is the distance from 0 and has no positive or negative value. Show symbol for absolute value. $\|x\|$ Which is larger? $\|-6\|\ or\ \|-8\|$ $\|+9\|\ or\ \|-10\|$	If students need more practice, additional examples in *Math for the Automotive Trade*, p. 100 problems #53–56

	Rule 1 for addition of signed numbers To add two signed numbers with like signs: • Add their absolute value • Use the common sign (+6) + (+5) $(\|+6\|+\|+5\|)$ (6+5) +11 (-8) + (-4) $(\|-8\| + \|-4\|)$ (8+4) -12 **Rule 2 for addition** To add two signed numbers with unlike signs: • Subtract their absolute values (smaller from larger) • Use the sign of the number with the larger absolute value. (-7) + (+5) = $(\|-7\| + \|+5\| =$ (7 – 5) -2 (+3) + (-12) $(\|+3\| + \|-12\|)$ (12 – 3)	

	-9 Next show students where some common fractions and decimals might fall on this line like +0.25, -3/4, -1/8, +0.75. Be sure to show students that some numbers are equivalent like +0.5 and +1/2. Then show a few less common fractions like -0.125, +.19 Show students how to add fraction and decimal sign numbers. Guided practice: 1. $\left(-\frac{1}{4}\right) + 0.125$ 2. $-0.7 + 0.9 + (-1.3)$ 3. $\left(-\frac{5}{8}\right) + \frac{3}{4}$ 4. $\frac{1}{16} + (-0.375)$ 5. The camber angle on a car is at (-1.25^0). The angle is adjusted and increased by 2.75^0. What is the new angle? **Subtraction of Signed Numbers** Remind students that subtraction is the opposite of addition	If students understand the concept of adding signed numbers without the use of a calculator, then some calculator use here, although not preferred, is acceptable.

	because now we are looking for a difference. Use a *number line* to demonstrate several simple problems like: 1. $9-2$ 2. $5-8$ 3. $(-3) - 7$ **Rules for Subtraction** 1. The first number does not change 2. The subtraction sign changes to an addition sign 3. The sign of the second number changes to its opposite 4. Solve like an addition problem Example 1 $2 - (-8)$ $2 + (+8) = 10$ Example 2 $(-15) - (-12)$ $(-15) + (+12)$ -3 Example 3 $(-15) - 3$ $(-15) + (-3)$ (-18)	Additional practice for adding and subtracting signed numbers

	Example 4 $$6 - 13$$ $$6 + (-13)$$ $$(-7)$$ Guided Practice 1. $(-11) - (-2)$ 2. $8 - 34$ 3. $44 - (-108)$ 4. $(-17) - 30$ 5. The caster angle on a vehicle was found to be (-0.5^0). After being corrected, the caster angle is 1.75^0. How much was the angel changed? Show students how to subtract fraction and decimal sign numbers. Guided Practice 1. $\left(-\frac{3}{8}\right) - \frac{3}{4}$ 2. $\left(-6\frac{2}{3}\right) - \left(-9\frac{4}{5}\right)$ 3. $-16.25 - 5\ \frac{7}{8}$	

	4. $48.7 - 63.1$	
	During a wheel alignment camber, caster, and toe can be adjusted. Camber – signed numbers are used to indicate the direction of wheel tilt. A positive camber means the wheel tilts outward from vertical. A negative camber would mean the wheel tilt would be inward from vertical. A camber of 0^0 would mean the wheel is vertical. Caster – is the tilt of the spindle and strut. A positive caster means the strut and spindle tilt away from the front of the vehicle while a negative caster means the spindle and strut tilt toward the front of the vehicle. A caster of 0^0 means there is no tilt in the spindle and strut. Toe – A toe adjustment makes sure that the wheels are running parallel to one another and rolling straight ahead. Depending on the vehicle manufacturer, specifications for camber, caster, and toe can be given in DMS or decimal degree, so it is important to be able to move easily between the two systems. Examples: 1. The camber reading of a wheel on a Dodge is -0.125^0. How large an adjustment must be made to	Use overhead transparences or some sort of pictures to describe these different angle to students.

	bring the wheel into specifications? The acceptable specifications for camber are -.0.02^0 to +0.8^0. 2. The rear camber for the same Dodge is also -0.125^0. If the preferred setting is -0.6^0 $\pm$ 0.5^0, will an adjustment need to be made and if so how much? 3. The toe on a similar dodge has a preferred setting of $\frac{3}{32}$". What is this reading in degrees of an inch? 4. The caster reading on a Nissan has a specified reading of 45' to 2^0 15'. If the mechanic wanted to put this reading at mid-range, what would the desired reading be?	This gives instructor and opportunity to discuss tolerance of a measurement. Additional Practice: *Math for the Automotive Trade*, p. 235 Automotive Mathematics, pp. 160 and 162
Working with Decimal/Fractional Degrees and Degrees and Minutes	Tell students there will be times they will need to convert between decimal degrees and degrees, minutes and seconds. Give students the following information. 60 minutes = 1 degree abbreviated, 60' = 1^0	If students do not yet have experience using unity fraction for conversion you might look at the fraction unit for more detailed instruction.

	To convert $18\frac{3}{4}^{0}$ to degrees and minutes, there are two steps to follow. Step 1 Write the angle measurement as a whole number and a fraction. $$18\frac{3}{4}° = 18° + \frac{3}{4}°$$ Step 2 Use a unity fraction to convert $\frac{3}{4}°$ to minutes. $$18° + \left(\frac{3}{4}° \times \frac{60'}{1°}\right)$$ $$18°45'$$ Show another example using a decimal degree Convert 78.4^{0} to degrees and minutes. Step 1 Write the angle measurement as a whole number and a fraction $$17.4° = 17° + .4°$$ Step 2 Use unity fraction to covert $.4^{0}$ to minutes.	

	$$17° + \left(\frac{.4}{1} \times \frac{60'}{1}\right)$$ $$17°24'$$ Guided Practice 1. $17\frac{2}{3}°$ 2. $46\frac{1}{4}°$ 3. $89\frac{5}{8}°$ 4. $231.7°$ 5. $51.9°$ 6. $83.6°$ Show students how to move from degrees and minutes to decimal form. Tell students there are two steps. Use 94^{0} 3' Step 1 Write the angle as a sum of degrees and minutes $$94° + 3'$$ Step 2	

	Use a unity fraction to convert minutes to degrees. $$94° + \left(\frac{3'}{1} \times \frac{1°}{60'}\right)$$ $$94.05°$$ Guided Practice: 1. 7^0 12’ 2. 22’ 3. 75^0 36’ 4. 111^0 48’ 5. 86^0 18’	
Adding and Subtracting DMS	Tell students that sometimes they will have to combine or find the difference between two sets of decimal degrees. Remind students that: **60 minutes = 1 degree abbreviated, 60’ = 1^0** Demonstrate how to add: $$\begin{array}{r} 22° \; 47' \\ \underline{+5° \; 33'} \\ 27° \; 80' \end{array}$$	Additional Problems with addition and subtraction in, *Math for the Automotive Trade*, pp. 78-79 *Automotive Mathematics*, pp. 150-151

	Tell students to take 60’ and add to degrees. Correct answer is $$27° \, 80' = 28° \, 20'$$ Demonstrate how to subtract: $$\begin{array}{r} 14° \, 12' \\ \underline{-6° \, 30'} \end{array}$$ Show how to borrow: $$\begin{array}{r} 13° \, 72' \\ \underline{-6° \, 30'} \\ 7° \, 42' \end{array}$$	
Specification Mid-Point	Tell students that often specifications are given in a range, which is the distance/difference between the highest and lowest number in a set of numbers. Example 1: A certain Nissan has a Caster range of 45’ to 2^0 15’. If you needed to set this at or near the midpoint of this range, what would your setting need to be? Step 1 Find the difference between the highest and lowest numbers. $$2° \, 15'$$	Not all vehicles require the setting to be at exactly the midpoint of the range; however, on the occasions when they do, this will be a useful skill.

	$\underline{-45'}$ $1°\,75'$ $\underline{-45'}$ $1°\,30'$ Step 2 Find the middle of the range by dividing by 2. $\frac{1°\,30'}{2} = \frac{90}{2} = 45'$ Step 3 The final step is to fine the actual midpoint of the particular specification with which you are working. a. You can add the 45' to the smallest specification number $45' + 45' = 90'\,or\;1°\,30'$ b. You can subtract the 45' from the largest specification number $2°\,15' = 1°\,75'$ $1°\,75' - 45' = 1°\,30'$ Either method (a or b) will work for this part of the calculation. Example 2:	

	Now suppose on the same Nissan you have a camber specification of -35' to 1^0 05' and you need to find the midpoint. Step 1 Find the total range. Change everything to minutes. $$1° \, 05' = 65'$$ Since one number is negative, simply add 35' to both the low and high range numbers, then find the difference between the two positive numbers. $$65' + 35 = 100'$$ $$-35' + 35' = 0'$$ Step 2 Find the middle range by dividing by 2 $$100 \div 2 = 50$$ Step 3 Either add to the smallest spec number or subtract from the largest a. $-35 + 50 = 15'$ b. $65' - 50 = 15'$	If students have a hard time understanding this, draw a number line for a visual of the problem.

	Either a or b will give the midpoint of the range of the specifications. Guided practice. Give students specifications to find midpoint of range or have them look up the specifications on their own vehicle and find the midpoint.	

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Speed and Feeds/Formulas and Charts

Purpose: The purpose of this unit is to introduce students to the different formulas and charts they will need to be familiar with in the machine shop to set the up different cutting machines. There are different formulas for different operations. The ones in this lesson may not be the ones an instructor uses. They are given here as examples. It is important the instructor discuss formulas, their variables, and order of operations for students to understand how to use them correctly.

Student Objectives:

- Use cutting speed charts to determine correct ft/min
- Calculate RPM
- Determine correct feed rate for material and application
- Understand Depth of Cut

Topic	Activity	Notes
Machine Tools	Go over different tools in the shop that will be affected by the speeds, feeds, and cutting depths like: • Lathes • Mills • Saws • Drills Tell students they will be working with charts and formulas to determine how to setup the machines for the best performance of the metal being cut and the cutting tools. Remind students they will be working with some very small numbers. A good understanding of decimal numbers is important.	For students with lower math skills, it is probably best to give them all formulas so they can concentrate on the work and not the algebra at this point
Reading Charts for Information	Bring examples of charts for students to see. These might include cutting and/or feed charts for different types of cutting	

	tools or materials. Pose certain questions for students and have them practice identifying information from the correct charts.	
Cutting Speeds	Define cutting speed as it relates to different machines (surface speed). Application Pose questions for students about cutting speeds for lathes in either standard fpm or metric m/min measurement and for different materials.	
RPM	Explain that RPM of the rotating work piece on the lathe or cutting tool on a mill is different from the cutting speed on the chart. Show students how to interpret the formula and what the variables mean. Give students examples and have them find the RPM for a Lathe or Mill using: Standard Units $RPM = \frac{CS * 4}{D}$ Metric Units $\frac{CS * 1000}{\pi D}$	Students often get confused differentiating between the CS and the spindle speed (lathe) or cutting tool (mill) Practice Problems: Mathematics for Machine Technology, pp. 261 – 262, problems 11-20 and 24-28
Depth of Cut	Explain depth of cut on a lathe and how it will affect the diameter. If depth of cut is set for .125", it is actually removing .250" from the diameter of the piece	Students with poor spatial skills might have to have this drawn out or seen in the shop to understand.

Feed	Explain feed Explain feed for rough cut and finish cut Give students feed charts to determine correct feed rates for a particular material and type of cut (rough or finish)	
Cutting Time	Explain importance of calculating cutting time and why it should be calculated. Give a formula for cutting time or work time like: $T = \frac{L}{FN}$ Be sure to explain the variables and give example or two how to solve	Practice Problems: *Mathematics for Machine Technology*, pp 261-262, problems 21-21, 34-36
Real-life Applications	Once students have grasp the different operations and what they tell, instructors might pose more complex situations where students will have to use critical thinking skills to solve the problems. Again, depending on student's math level, rearranged formulas may have to be substituted at this point.	Practice Problems: *Mathematics for Machine Technology*, pp 263-264, problems 39-58

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Statistical Process Control

The purpose of this unit is to introduce students to Statistical Process Control. Basic understanding of decimal operations as well as comparing decimals will be important for this unit.

Student Objectives

- Calculate mean and range of sets of numbers
- Define and understand standard deviation
- Calculate standard deviation with a calculator
- Fill out X-Bar and R chart

Topic	Activity	Notes
Standard Deviation Mean	Explain importance of standard deviation and why it is used to check work in the manufacturing process to check for error. Show students how to calculate mean of a set of data Give students examples of data with which to practice so they can calculate the mean to the given dimensions of the part with its tolerance. Example: A print dimension for a part is 2.375 $\pm .010$ Tell students they must find the mean of the following set of data that was measured with a caliper. Tell students they need to indicate any parts that are out of spec.	For this lesson you will need 1. Student copies of SPC chart with 25 subgroups of 5 measurements with speck limit and data already entered. You will also need to indicate the dimension with tolerance. 2. Student copies of a Control Chart to graph averages (X-Bar chart) and ranges (R-Chart) in separate areas

	2.377, 2.367, 2.365, 2.379, 2.384, 2.376, 2.386, 2.381, 2.382 Give students formula and explain what it means. $Mean = \bar{x} = \frac{\sum x}{n}$ Give other examples of real data if possible for students to practice.	
How to Find Standard Deviation	Give students the process using "n-1" standard deviation. You may want to show them the steps manually before you let them use the calculator. 1. Find the mean of a set of data 2. Subtract the average from each score 3. Square the difference 4. Find the sum of the squared differences 5. Divide that sum by the number in the set of data 6. Find the square root of that number. Give the standard deviation formula and show students how to use it. $\sigma_{n-1} = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$ Give students plenty of examples to practice finding the $\bar{x}$ and the σ_{n-1}	
Range	Explain range of a set of data.	

	Give students several sets of data to practice calculating range. You might also have them practice finding the $\bar{x}$ Explain what is meant by R-Bar or $\bar{R}$ Give students worksheet: Charting Data on an X-bar and R Chart Explain chart Have students calculate and fill out X-bar and Range Explain $\bar{\bar{X}}$ and $\bar{R}$ Have students calculate $\bar{\bar{X}}$ and $\bar{R}$ for Charting Data on X-bar and R Chart they just completed. Hand out student copies of Control Chart. Explain chart. Students are to plot 25 X-Bar points and 25 ranges. Have students analyze chart looking for pattern as well as trends that might be problematic. Explain control limits and how to solve: X-Bar Upper Control Limit (UCL_X) = $\bar{\bar{X}} + A_2\bar{R}$ X-Bar Lower Control Limit (LCL_X) = $\bar{\bar{X}} - A_2\bar{R}$ Range Upper Control Limit (UCL_R) = $D_4\bar{R}$ Have students add control limits to chart.	

	Students again analyze for points outside of control limits.	Information for this lesson used by permission from *Mathematics for Manufacturing*

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The CASE grant project ($18,679,289) is 100% funded through the US Department of Labor's Trade Adjustment Assistance Community College and Career Training program.

Teacher Notes

This curriculum was developed by Blair Brawley, ABS Math Instructor, with assistance from COCC Automotive Technology faculty.

Basic Automotive Math is a non-credit Adult Basic Skills contextualized math curriculum designed to assist students in developing the necessary math skills needed to complete the automotive curriculum at Central Oregon Community College. This curriculum is written for Automotive instructors or someone with a math background and a strong knowledge of the automobile.

Resources:
Listed below are the resources referred to in this curriculum. All have their merits and shortcomings as do most math textbooks, so instructors will have to choose the one most appropriate for their own program.

1. *Math for the Automotive Trade*, 5th ed., John Peterson and William J. deKryger; Delmar, Cengage Leaning
   After a review of basic skills, this text takes on a more Learning Standards approach by going through systems in the car using all math involved. Appendix B has a summary of formulas used throughout the text. This book offers good on-line resources for the instructor.
2. *Automotive Mathematics*, Jason c. Rouvel; Pearson Prentice Hall
   Another good choice, this textbook has a stronger focus in some areas such as gear ratios and unity fractions.
3. *Practical Problems in Mathematics for Automotive Technician*, 5th ed., Sformo and Moore, Delmar
   This is a great little book for someone just wants practice problems for their students. It has only a very few practice examples and the practice does not go into the depth that the first two resources noted here have. There is a later version of this text very similar to the one used here.
4. http://www.austincc.edu/autotech/public_html/activity.pdf
   Student workbook from the automotive program at Austin Community College is filled with NATEF aligned series, parallel, and series-parallel circuit worksheets. Each set is scaffold to meet learner's needs. See pages 9-21.

Lesson Progression:
This curriculum is currently used in the following sequence.

Basic Automotive Math

- Introduction to Automotive Mathematics
- Decimals
- Fractions
- Ratios and Proportions

After these skills along with their contextualized examples have been covered, any of the other units or parts of units can be used as needed. As time is an issue in automotive programs, parts of these units can be pulled out and used. For example in the Fractions unit, an instructor may want students to use fraction multiplication for a certain task. Instructors can pull out those necessary skills and then move on to the application necessary to teach the task at hand.

The only other progression of units might be that of Plane and Three Dimensional Geometry.

Curriculum Notes

- When introducing a new math topic like fractions or decimals, make sure students know application possibilities up front. This will encourage student buy-in to a lesson when they understand why they need to know it.
- Actual addition, subtraction, multiplication, and division computation skills of fractions and decimals is left to instructor discretion; however, some application problems are given on each topic.
- Calculator use always creates a debate. Although not specifically stated in the individual units, this curriculum uses examples in the beginning of most lessons to encourage deeper understanding of concepts before the use of calculators.
- Accuracy and rounding should continually be addressed. Depending on topics and desired results, students need to understand how rounding a number may at times affect an outcome and other times it does not.

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Three-Dimensional Geometry

Student Objectives:

- Understand and calculate volume of a right cylinder
- Understand cubic units
- Calculate cylinder displacement
- Calculate total engine displacement

Topic	Activity	Notes
Working with Volume and Cubic Measurements	Open with asking students if they understand what cubic measurement means. Review how linear units differ from square units. Show students examples of 3-dimensional (solid) shapes, explaining why these units are referred to as cubic units. Show students how to express cubic units, using inches to demonstrate • Cubic inches • cu in • in^3	Bring in different examples of solid objects like cylinders, boxes – anything with height, width, and depth.
Review Parts of Circle	Review basic parts of a circle • circumference • diameter • radius	If students are not familiar with the area of a circle or its parts, go back to unit on plane geometry

	• area • π Review: To find area of a circle **Area =** πr^2	
Which Is Better?	Opening demonstration: Carefully tape paper in two cylinder shapes creating one long cylinder and one short cylinder. Be careful not to tape over the edge. Ask students if they think the cylinders will hold the same amount since they are made from the same size paper. Let them give answers. Put newsprint under shorter cylinder so popcorn does not go everywhere. Pour the popcorn into the shorter cylinder. Ask students if they think the same amount will fill the taller cylinder. Put newsprint under taller cylinder and carefully pour popcorn	For this demo you will need two sheets of 8.5 x 11 inch paper, tape, popcorn without salt or grease, and a sheet of newsprint

	from the shorter to the taller cylinder. Ask – what happened? Increase of stroke or bore? Without going into a huge conversation (good luck on this), ask students which would be better – to increase the bore or the stroke of an engine to gain better performance. Obviously either one is going to increase performance somewhat. Increase in stroke gives better low-end torque. Increased bore gives more actual displacement so the valves can be bigger and chamber swept clean quicker and more efficiently. With either change, parts have to be changed and none of this is cheap. It is easier (but not necessarily cheaper) to get the more hp out of an increased bore than stroke, but of course you can only increase the bore by so much because of the heat carry over between cylinders. Also depends on block size.	 (*The increase in the radius gives more volume to the cylinder even though the surface area of both shapes is the same)*
Finding Volume of Cylinder	Once students understand how to find the area of the circle, they simply have to multiply it by the height to find the	

	volume. If students are having trouble with this concept show them how the area of the circle with a height of 1” stacks up to create the height of the cylinder. **Volume of cylinder = $\pi r^2 h$** Most automotive textbooks will show this as: **Volume of cylinder = 0.7854 X bore^2 X stroke** If you have an engine bore of 3.56” and a stroke of 3.9375”, what is the piston displacement for that cylinder? $0.7854 * 3.56^2 * 3.9375$ If this is the displacement for one cylinder; however, your engine has 6-cylinders. What would the total engine displacement be? 39.19 * 6 = 235.14 or 235 in^3 You could do this another way using the formula $\mathbf{0.7854 * d^2 * h * number\ of\ cylinders}$ $0.7854 * 3.56^2 * 3.9375 * 6$ = 235.14 or 235 in^3	This can also be written as $0.7854d^2h$ Practice Problems: *Math for the Automotive Trade*, pp. 42,165-166 (problems 6,7,8 and 9) *Automotive Mathematics*, p. 181-182

	<u>Challenge question:</u> You have a cubic inch displacement of 34.0739 in one cylinder and a stroke of 3.307 inches. Find the bore. Let students play with this and see if they can find the correct answer. (ans. 3.622 inches) Take the total displacement of the cylinder and divide by the stroke times 0.7854 Take that answer and find the square root. Be sure to tell students not to round until the end. $\frac{34.0739}{.7854 * 3.307} = 13.11887979$ $\sqrt{13.11887979} = 3.621999419$ or 3.622 inches	

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Triangle Math

The purpose of this unit is to introduce students to triangle math. This unit begins with review of basic triangles. Pythagoreans Theorem and basic right angle trig is also discussed. Students will need a strong understanding of ratios, decimals, and evaluating formulas to be successful in this unit.

Student Objectives

- Identify sides of right triangles by name
- Use Pythagorean Theorem to solve right triangle
- Identify and solve for angles and sides of right triangles using basic trigonometry ratios
- Solve problems relating to taper
- Understand and work with Bolt Circles
- Make sin bar calculations

Topic	Activity	Notes
Introduction and Basic Review	Talk about triangles and their importance in things like lay out in the manufacturing industry. Review different angles discussed in Geometry Unit – • Acute • Obtuse • Straight • Right Show students different types of triangles – going over attributes and names of each. Explain and demonstrate how all triangles are 180^0	Be sure to focus on vocabulary reminding students they will need to speak this language. Practice Problems:

	Show students how to find missing angles Show students how to find corresponding sides of triangles Review basics of ratio and proportion Show students how to solve similar triangles	*Mathematics for Machine Technology*, pp. 309-311 Practice Problems: *Mathematics for Machine Technology*, pp. 318 – 319
Pythagorean Theorem	Introduce students to Pythagorean Theorem $a^2 + b^2 = c^2$ Tell students why they need to know it and give them practical examples from shop application. Show students how to solve for vertical and horizontal sides (legs) and the hypotenuse.	If students have not yet taken an algebra class or worked with rearranging formulas, give students the different formulas to find sides a, b, and c. If students have taken beginning Algebra, work with them to rearrange the formulas *Mathematics for the Trades*, p. 623, problem set C
Solving Special Triangles	If desired, instruction can include solving special triangles instead of using Pythagorean Theorem to solve for sides. Since these are common, students can use them to quickly solve problems Tell students that these are common triangles in trig Show students how to solve 45/45/90 triangles Show students how to solve 60/30/90 triangles Show students how to solve 3-4-5 triangle	Practice problems and additional explanations can be found in: *Mathematics for the Trades*, pp.618-622; p. 623 problems 11-20 Mathematics for Machine Technology,
Trigonometric Functions	Explain to students why they need trig, in addition to	It will help if students understand that all

	geometry and algebra, to solve problems they will encounter on the job. Tell students that some of this might seem overwhelming at first, but these are needed skills for success in daily machine shop operations. Calculation of slots and chamber depths as well as working with bolt circle calculations and taper angles will need right angle trigonometry. Explain ratio of right triangle sides. Draw examples on the board. Show students how to identify adjacent, opposite and hypotenuse sides of the right triangle. Give students Sine, Cosine, and Tangent functions. $SIN = \frac{OPP}{HYP} \quad COS = \frac{ADJ}{HYP} \quad TAN = \frac{OPP}{ADJ}$ Tell students these are easy to memorize with the following: SohCahToa Model finding functions like find the sin 44^0 or the cos of 77^0	they are doing is working with ratios. If necessary, go back and review ratio section. Do not skip this practice. Students need to be able to quickly identify what they are working sides and angles with which they are working. Practice Problems: *Mathematics for Machine Technology*, pp. 416-418 Tell student to come up with ways to remember this like – Oh Heck Another Hour Of Algebra (of course they will have to remember the S-C-T) Do not plan to get through this too quickly. Students will probably have different calculators and will need time to learn how to enter information.

	Give students problems to practice. Include harder problems like the tan of 56^0 18’ or sin of 35^0 15’ 22” when they are ready.	Students may need to go back and practice changing these to decimal degrees or refresh how to enter DMS on their calculators. Practice Problems: *Mathematics for Machine Technology*, p. 419, 24-53
	Give students the following rearranged formulas from the 3 basic formulas. $HYP = \frac{ADJ}{COS}$ $HYP = \frac{OPP}{SIN}$ $ADJ = COS * HYP$ $ADJ = \frac{OPP}{TAN}$ $OPP = SIN * HYP$ $OPP = TAN * ADJ$ Give students plenty of practice working with these formulas.	Tell students that with these 9 formulas and Pythagorean Theorem, they have some very powerful math. Remind students that this all deals with Right Angle Trig. The triangle with which they are working must have a 90^0 angle or they must be able to create a right angle triangle inside the larger triangle with which they are working. Practice Problems in *Practical Problems in Mathematics for Manufacturing*, pp. 192-194, problems 1-7 will give students an overall good introduction to practical applications. Most students, especially those with poor spatial skills may have difficulty and need additional instructional assistance.
	APPLICATIONS **Sin Bar and Gage Block Height** Demonstrate how to use sin bar and gage blocks Have students determine gage block height from several different angles.	Bring examples to class so students can see how this works.

	Tapers Model how to use perpendicular bisector to create 90^0 angles in isosceles triangle. (good example problem in *Practical Problems in Mathematics for Manufacturing*, p. 195, problem 10) **Bolt Circles** Show students how to calculate degrees in bolt circles. Show students how to calculate distance between equally spaced holes.	Practice Problems: *Mathematics for Machine Technology*, p. 439, problem sets 1 and 2 *Practical Problems in Mathematics for Manufacturing*, pp. 198 – 200 Practice Problems: *Practical Problems in Mathematics for Manufacturing*, pp. 196 – 197 *Mathematics for Machine Technology*, pp. 439-440 Practice Problems: *Practical Problems in Mathematics for Manufacturing*, p. 195, problems 8,9 *Mathematics for Machine Technology*, p. 440, problems 9,10

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Unit 1: Introduction to Basic Manufacturing Math

The purpose of this unit is to introduce students to good math habits, class time management, and whole number operations.

Note to Instructor: This unit will take more than one work session to complete; however, skills included are important for student success in all other units in this curriculum.

<table>
<tr><td colspan="3">Student Objectives
Understand the importance of note taking
Recognize and use the different symbols and operations in arithmetic
Use Order of Operations
Understand and use the problem solving process to solve problems and communicate their results</td></tr>
<tr><th>Topic</th><th>Activity</th><th>Notes</th></tr>
<tr><td>Note Taking

Time Management</td><td>Explain note taking process
Write summary of important facts
Write in your own words
Leave plenty of white space to add additional info later
Highlight key concepts and words
Rewrite and refine notes as soon as possible
Key words and definitions
Explain the importance of keeping a separate list of key words and their definitions
In addition to class notes, it is important for students to create a separate formula sheet to which they can refer.
<u>Time Management</u>
Have students fill out a calendar of their weekly schedule. This should include things like work schedule, scheduled class times, family</td><td>Students need to understand why it is important to take notes and how to do it.

Keeping separate lists is important for several reasons. It not only keeps important information in one place, but by copying and refining information, it will assist in students learning the material.

Since manufacturing classes are self-paced, time management can</td></tr>
</table>

	responsibilities, and personal schedule. Tell students that because the manufacturing courses are all independent study, they also need to commit to times they will be in class/lab as well as well as necessary study times.	become a real issue for students. Procrastination is a problem. Helping students see how to manage their time will be a great help in the long run.
Symbols and Operations	Discuss important symbols and operations with students. This will include operation symbols for addition, subtraction, multiplication, division, powers, and roots as well as proper use of the equal sign. Depending on students' level, this may or may not be an appropriate time to mention +/- symbols for signed numbers. For manufacturing students the basic symbols for diameter...radius…etc. are covered in Blue Print Reading course; however, this may be a good opportunity to go over the more common notations here.	
Number Properties and Order of Operations	Commutative Property of Addition Commutative Property of Multiplication Associative Property of Addition Associative property of Multiplication Identity property Zero properties of addition and multiplication Write the following problem on the board and ask students to solve. $\{5 + [7 - 3(6 - 4) + 2] - 6\} + 1$ Record their answers on the board. Ask students why people got different answers. Tell students that the mathematical operations and formulas used in	It is not important for students to know the names of certain number properties; however, it is important for students to understand how the numbers work together. A mention of this now and then later for reinforcement of these properties is extremely important. Although working with whole numbers is not common in manufacturing, an understanding of the basic order of operations is very important. Spending a little time

	the manufacturing industry here in the USA are the same ones used in other countries as well. It is important for computation to be done in the same order around the world. A standard order of operations has been established for this purpose. Go back to problem and show students how to properly work steps. Write PEMDAS on the board. Explain PMDAS in detail **Parentheses (P)** – First do all work in parentheses. In a problem expressed in fractional form, the numerator and denominator are each considered as being enclosed in parentheses. This includes any operations that are enclosed by (), {}, and []. If more than one set of inclusion signs is used, you work from the inside out. Order of operations is used inside of the signs of inclusion if two or more operations are found there. *(9+3-4*2)* **Exponents (E)** - Second take care of all powers and roots in order from left to right. **Multiplication and Division (MD)** – The third step is to take care of all multiplication and or division as it occurs in the problems as you read it from left to right. A common error that students make is to go through and do multiplication and then go back and do division. This will not work. **Addition and Subtraction (AD)** – The fourth and final step is to clear up all the addition and subtraction working from left to right. As with the multiplication/division step, this operation is done in one step, not two.	now on the basics makes a much easier transition for students as they begin working with decimals and fractions. DO NOT encourage students to combine steps; while learning, they should do each step. For students whose knowledge is limited in working with powers, have students expand them in an additional step. $2 + 5^3$ $2 + (5 * 5 * 5)$ $2 + 125$ 127 Make sure to emphasis that multiplication and division is one step as you read the problem from left to right Make sure to emphasis that addition and subtraction is one step as you read the problem from left to right

	Practice Examples 1. $2 + 6 \times 8$ 2. $16 + 32 \div 8$ 3. $12 - 7 - 3$ 4. $12 - (7 - 3)$ 5. $(11 - 2 \times 3) \div 5$ 6. $\frac{44+12}{11-3}$ (Be sure to point out that the fraction bar is also used as a sign of inclusion)	Students need plenty of practice so they can later transfer these skills fraction and decimal applications as well as working with formulas used in the trade. Be sure to emphasis that this skill will be continually used and it is important for students to ask questions and feel confident in working with order of operations. <u>Additional problems</u> can be found in , *Mathematics for the Trades*, pp. 51-52 and calculator problems can be found on pp. 53-54 *Practical Problems in Mathematics for Manufacturing,* pp. 159

Problem Solving Process	Problem Solving Process
	• Read and understand the problem <u>including all instructions</u>
	• Identify important information that is given and make note of it
	• Identify the exact question(s) – write it(them) down
	• Identify other information that you might need such as a specific formula or conversion factor
	• Develop a plan to solve the problem and write it down
	• Estimate an answer
	• Solve the problem
	• Check
	    o Did you solve the question you identified?
	    o Does your answer make sense?
	    o Did you label your units?
	
	This seems like a long list, but as you practice this process it will eventually become automatic.
		Either have students take notes or make a handout for students. In either case, go over each step in detail and check for student understanding .
		
		For estimation, tell students that this is an ongoing process that will be taught throughout the course.
		It will be the teacher's responsibility to model estimation in its many forms when possible.

	Example Problems <u>Problem 1</u> A rectangular shop space is 10 yards wide and 12 yards long. What is the area of the shop space in square yards? • Read the question • Identify info given – *12 by 10 workspace* • What is the question? – *looking for* ***<u>area</u>*** *of the room in* ***<u>square yards</u>*** • What else do you need to know? *What is area?* *What is meant by square yards?* *Formula to find area of a rectangle* • Plan: Using the formula for the area of a rectangle (length x width), I need to multiply 10*12 to find the square yardage. • Estimate – Well 10*10 is 100 plus two more 10s (10 +10= 20) that's about 120 square yards • 10*12 = 120 square yards Did you <u>solve the question</u> you identified? *Yes* Does your answer make sense? *Yes (check against estimate)* Did you label your units correctly? *Yes – square yards* Ask if students were able to solve this problem without going through this process. (some will probably say yes) Explain that this is because they already understand the problem and how to solve it. As they are introduced to new skills, formulas, and topics, they will have to refer to this process to keep their thoughts organized. Tell students to never leave any problem blank.	Work through this entire process with students.

	Often if students are "stuck" on solving a problem, referring back the problem solving process and working through the steps will assist them with clues complete the work. Problem 2 A gallon of oil has a volume of 231 in^3 per gallon. If a storage tank holds 420 gallons of oil, what is the volume of the tank in cubic inches? Problem 3 A machine shop purchased 11 steel rods of $\frac{7}{8}$ " diameter steel, 22 rods of $\frac{1}{2}$ " diameter, 7 rods of $\frac{1}{4}$ " diameter, and 18 rods on 1" diameter. How many rods were purchased?	Model the two example problems for students using the problem solving process. This gives a good opportunity to explain difference between *cubic* and *square* units as well as notations for both. This problem is a good example of information that is not necessary to solve the problem. Students tend to get confused by all of the numbers. Additional Problems can be found in *Mathematics for the Trades*, selected problems on pp. 15-16, 18, 25, 36, 38, 46-48, 58-59. *Practical Problems in Mathematics for Manufacturing,* pp. 2-8, 10-16.

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Unit 2: Fractions

Purpose of this unit is to build student's skills with fractions that will be used in the manufacturing industry. This unit does not have to be done in a linear fashion. For example if working with students to build addition skills, it would be important to review the building fractions with common denominators and reducing fractions to lowest terms. If working with multiplication and division it would be important for students to understand changing between mixed numbers and improper fractions as well as reducing fractions.

Students will be introduced to skills in this section that will carry over to measurement and ratio/proportion type calculations, so gaining an understanding here will help them with future job calculations.

Student Objectives:

- Understand importance of fractions in the manufacturing industry.
- Manipulate different types of fractions and operations (add, subtract, multiply, divide, order of operations with fractions).
- Use fractions to solve problems related to the manufacturing industry.

Topic	Activity	Notes
What are fractions and why do you need to understand them?	Begin with a brief discussion of why we would have a use for understanding fractions and how they are used in the manufacturing process. Tell students that although fractional measurements are not used as often as decimals in manufacturing, it will be important for them to understand how to manipulate fractions solving a variety of problems. See if students can name things like using rulers and tape measures as well as tolerances. See what other previous knowledge they have on this topic. Prod their thinking if	It is important because of all the rules involved with using fractions that students have some sort of knowledge about why they need to know about fractions before proceeding. If students understand some of the applications they need to use, it will be much easier to keep their interest.

	necessary by giving additional examples such as cutting stock, calculating waste, measuring thread pitch, etc.	
Using a Tap Chart	This is an important chart to read correctly. Remind students that a smaller hole can always be made larger, but if you drill a hole too large, it is hard, if not impossible, to fix your mistake. With taps, if the pilot hole it too large, there is no material left in which to cut the threads. Use a document camera to explain the different sections of the chart. Show students how to choose the correct tap drill and tap for a particular job. Example if you want to cut $\frac{1}{2} - 20$ UNF hole. Show students the columns. Explain Tap size, TPI(threads per inch), Drill Size, Decimal Size The choice would be a $\frac{29}{64}$ inch drill to cut the treads for $\frac{1}{2} - 20$ UNF Tell students the tap drill size is often stamped on the tap itself or on a chart that is included with the tap and die tool set. <u>Guided Practice</u> Using the chart, give students additional problems like the one above.	Have a copy of a Recommended Tap and Drilled Pilot Hole chart available. Sample chart available in Practical Problems in Mathematics for Manufacturing, Appendix p. 241 Bring a tap & die set and a drill index for students to see. Although this is a very simple application for fractions in the manufacturing in field, it will give instructors an opportunity to evaluate the level of student knowledge on bolts and threads. Depending on your curriculum as well as students' previous knowledge, this may be a good time to begin a discussion on the different types of taps and threads.

Types of Fractions Changing Between Mixed Numbers and Improper Fractions	Common and mixed numbers Define proper fraction and name the parts Write a few examples on the board making sure students understand the concept of part and whole (numerator and denominator) $\frac{1}{2}, \frac{3}{8}, \frac{9}{16}, \frac{13}{32}, \frac{23}{64}$ Define an *improper fraction* and explain its parts (numerator will be larger than denominator because it is more than one whole) Write examples on the board, again making sure students understand concept. $\frac{9}{2}, \frac{13}{4}, \frac{11}{8} \dots$ Segue to mixed numbers, telling students these are simply whole numbers and fractions combined like the number $4\frac{1}{2}$. Tell students that mixed numbers and improper fractions are the same number expressed different ways. You might give some examples of when you would use a mixed number and when you would need to use an improper fraction. • For example in giving a measurement number you would most likely say $4\frac{1}{2}$" not $\frac{9}{2}$". • On the other hand, when you are <u>multiplying or</u>	

	dividing fractions you would have to use the improper fraction form of $\frac{9}{2}$. Draw 5 circles on the board and draw a line through the middle of each circle from top to bottom. Roughly, color in all but one-half of the 5th circle. Describe how this model illustrates $4\frac{1}{2}$ • Count four whole circles and then $\frac{1}{2}$ of the last circle Describe how this model illustrates $\frac{9}{2}$ • Count each of the halves individually • There are 9 and each represents $\frac{1}{2}$, so you have $\frac{9}{2}$ Do more examples if necessary until students understand the concept that these both represent the same number just in different forms. Tell students that they probably don't want to draw circles to figure out how to change between mixed numbers and improper fractions, so now that they understand these numbers are the same, you can show them how to change forms. Show students how to divide the denominator into the numerator. Tell students that the remainder becomes the numerator over the denominator of the original number. Model this for students:	Refer back to 5 circle drawing for students to see you are basically doing the same thing.

	$\frac{9}{2} = 9 \div 2 = 4r1$ The *r1* becomes a numerator of 1 over the denominator of 2 because you are dealing with halves $\frac{1}{2}$ Your final answer would be $4\frac{1}{2}$ Try another problem like $\frac{33}{8}$ $\frac{43}{8} = 43 \div 8 = 5r3$ The *r3* becomes a numerator of 3 over the denominator of 8 since you are dealing with eighths. Your final answer will be $5\frac{3}{8}$ Show students how to change mixed numbers to improper fractions. Draw the 5 circles cut in half to model the $4\frac{1}{2}$ Tell students since you have 4 whole parts, if you multiply them by 2, it will give you the total amount of halves. You add the last half (in the 5^{th} circle) for a total of 9. Since you have been working with halves, it is $$4\frac{1}{2} = \frac{4*2+1}{2} = \frac{8+1}{2} = \frac{9}{2}$$ Model another example:	It will be important for instructor to move around the class making sure students are doing this process correctly.

	$6\frac{3}{4} = \frac{6*4+3}{4} = \frac{24+3}{4} = \frac{27}{4}$ <u>Guided Practice:</u> Change the following improper fractions to mixed numbers. 1. $\frac{37}{4}$ 2. $\frac{18}{4}$ 3. $\frac{72}{8}$ (good time to mention can be a whole number) 4. $\frac{292}{64}$ Change the following mixed numbers to improper fractions. 5. $3\frac{3}{8}$ 6. $7\frac{4}{5}$ 7. $10\frac{2}{3}$ 8. $5\frac{7}{32}$ <u>Check for Understanding</u> While students complete guided practice, be sure to walk around to check their work and understanding of the process.	Additional Practice Problems: *Mathematics for Machine Technology*, pp. 6-7 problem sets 8,9 *Mathematics for the Trades,* pp. 79 – 80, sets A and B
Equivalent Fractions	Introduce benchmark fractions like $\frac{1}{2}$ = 0.5 = 50% Ask students if they know what a number divided by itself is equal to such as $\frac{4}{4}$ Tell students that any number divided by itself is equal to 1.	This is ongoing information for students and they should be reminded of this often that fractions, decimals, and percents are the same thing – but different forms are used for different applications.

Building Fractions	Segue to equivalent fractions. $\frac{1\times\mathbf{2}}{2\times\mathbf{2}}=\frac{2}{4}$ Since each time $\frac{1}{2}$ is multiplied by a form of 1, it does not change its value; it only changes the size of the parts. To illustrate, draw a circle on the board and divide it in half. Color in half the circle to represent $\frac{1}{2}$. Next, cut the circle in half again so now the circle is divided into fourths. Show students that $\frac{2}{4}$ is actually the same amount as $\frac{1}{2}$. You can continue to cut the circle: 6ths $\left(\frac{3}{6}=\frac{1}{2}\right)$ and 8ths $\left(\frac{4}{8}=\frac{1}{2}\right)$ $\frac{1\times\mathbf{3}}{2\times\mathbf{3}}=\frac{3}{6}$ $\frac{1\times\mathbf{4}}{2\times\mathbf{4}}=\frac{4}{8}$ Tell students you want them to build two fractions so they have a common denominator.	Additional Practice: *Mathematics for Machine Technology*, p. 6, set 7 a-i. Once students understand the concept of equivalent fractions, it will be much easier for them to learn to build them to have common denominators then then move on to the addition and subtraction processes.

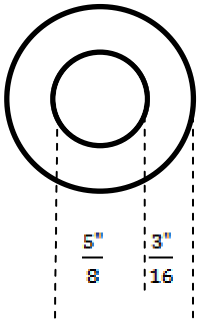
	This is an important skill for student so they can add and subtract fractional parts. Show students how to build two fractions like $\frac{3}{4}$ and $\frac{5}{16}$ Ask students to look at the two denominators and see if they have common factors. Prod students to compare the 4 and the 16. Show students that you can build 16^{ths} out of the 4^{ths}, by multiplying by a form of 1 like $\frac{4}{4}$ $\frac{3 * 4}{4 * 4} = \frac{12}{16}$ Tell students that since the other fraction is already in 16^{ths} you can now compare, add or subtract these fractions easily. Model another example like $\frac{3}{8}$ and $\frac{4}{5}$ Tell students since the denominators don't have anything in common, both fractions will have to be built to common denominators. Tell students that the factors of the denominators need to be the same.	*Factor* is a term that should have been covered in whole number multiplication, but if not, this is a good time to explain it to your students.

	Show students how to build fractions using forms of 1 from the opposite fractions. $\frac{3 * \mathbf{5}}{8 * \mathbf{5}} = \frac{15}{40}$ $\frac{4 * \mathbf{8}}{5 * \mathbf{8}} = \frac{32}{40}$ Now give students one more example and tell them to build fractions to LCD. Write 3 fractions $\frac{2}{5}, \frac{5}{6}$, and $\frac{7}{10}$ on the board Ask students what the smallest number each of these denominators will divide into. Write the multiples of 10 on the board and work through this with the students. 10 – 5 is a factor but not 6 20 – 5 is a factor but not 6 30 – both 5 and 6 are factor Tell students they should build all three fractions to 30ths. $\frac{2}{5} = \frac{x}{30}$	Although there are different ways to find a common denominator, basic visual factoring is used here. Be sure that students understand that multiplying by opposite denominators in the form of 1 like $\frac{5}{5}$ will not always give the least common denominator LCD

	$\frac{2*\mathbf{6}}{5*\mathbf{6}}=\frac{12}{30}$ $\frac{5}{6}=\frac{x}{30}$ $\frac{5*\mathbf{5}}{6*\mathbf{5}}=\frac{25}{30}$ $\frac{7}{10}=\frac{x}{30}$ $\frac{7*\mathbf{3}}{10*\mathbf{3}}=\frac{21}{30}$ Do more examples if necessary. Guided practice: Build fractions to Common Denominator or LCD 1. $\frac{1}{2},\frac{3}{32}$ 2. $\frac{3}{8},\frac{5}{64}$ 3. $\frac{1}{5},\frac{1}{3},\frac{5}{8}$ 4. $\frac{2}{7},\frac{3}{28},\frac{9}{14}$	Additional problems: *Mathematics for Machine Technology*, p. 11 Problems 1-4.
Reducing Fractions	Tell students that reducing fractions will become a common part of their work.	

	Ask students if they have a $\frac{6}{16}$" wrench in their toolbox. Show how to reduce by eliminating common factors: $\frac{6}{16} = \frac{\cancel{2} * 3}{\cancel{2} * 8} = \frac{3}{8}$ Now ask students if they have a $\frac{3}{8}$" wrench in their toolbox. Try a few more on the board so students get the idea of pulling out common factors. $\frac{44}{64}$, $\frac{14}{32}$, $\frac{12}{16}$	There are other ways to reduce fractions; however, if students understand this concept of eliminating common factors in the numerator and denominator, they will transfer this skill to higher-level math courses. Additional Practice *Mathematics for the Trades*, p. 115, problems 17-24 *Mathematics for Machine Technology,* p. 6, problems set 5 a-j p. 7 problem 11
Reading a Fractional Steel Rule *The purpose of this activity is to not only teach students how to read a steel rule but also to show the significance of properly reducing fractions to lowest terms.*	Tell students that today we will be working with steel rules. We will be learning about different scales and how to interpret them correctly. Tell students that the most common fractional rules in the manufacturing and welding labs will probably be $\frac{1}{16}^{th}$, $\frac{1}{32}^{nd}$, and $\frac{1}{64}^{th}$ scales. (Tell students that there are also steel rules that are graduated in 50^{ths} and 100^{ths}. These will be discussed in the decimal section of the curriculum.)	Bring examples of fractional steel rules with different scales for students to examine. If not available have overheads or handouts for students to use. Document cameras will also work well if available. Depending on students' level, it might be

	Ask students what is meant by a steel rule's scale. Draw a long number line on the board with 0 on one end and 1 on the other end. Tell students that this number line represents 0" to 1" on a rule. Cut the line in half. Tell students this represents $\frac{1}{2}$". Draw a line halfway between the 0 and the $\frac{1}{2}$. Ask students what they think this might represent. Do the same thing between the $\frac{1}{2}$"and the 1. Tell students that each of these lines represents $\frac{1}{4}$ of an inch. Tell students that now we have $\frac{1}{4}$, $\frac{2}{4}$, and $\frac{3}{4}$ marked on the number line between the 0 and the 1. Explain to students that now we have a scale of $\frac{1}{4}$ inch because each mark indicates $\frac{1}{4}$th. Go back to the $\frac{1}{2}$ inch and show students how this is the same as $\frac{2}{4}$ inch. Tell students that the entire steel rule is an exercise in reducing	helpful to start with a ½-inch scale and then a ¼-inch. It is important for students to understand that ½ of a half is ¼ and so on. Make sure when drawing the intersecting line between the 0 and the 1, that the intersecting line is shorter than the ends. When drawing these intersecting lines for 4ths, make sure these lines are a bit shorter than the $\frac{1}{2}$" intersecting line. Continue with this process making sure the 8ths are shorter than the 4ths and the 16ths are shorter than the 8ths. It is helpful if you bring in objects for students to measure to practice this skill. Additional problems can be found in: *Mathematics for Machine Technology*, pp. 154-155 *Mathematics for the Trades*, pp. 314-317

	fractions. Continue with $\frac{1}{8}$ inch, $\frac{1}{16}$ inch showing student how the fractions reduce and the lines get shorter as each section is divided into smaller pieces.	
Adding Fractions and Mixed Numbers Adding Applications	Show students how to add fractions with common denominators. Give students problems to practice. Show students how to build fractions to have common denominators and then use them to add and then give students problems to practice. Show students how to add mixed numbers with or without common denominators and then give students problems to practice.  Example: The cross-section of a hose Shown on the right has an inside diameter of $\frac{5}{8}$" and a wall thickness of $\frac{3}{16}$". What is the overall *diameter* of the hose?	Practice Problems can be found in: *Mathematics for the Trades*, p. 109, section A mixed addition and subtraction problems and p. 116, section C, mixed practice of addition and subtraction of fractions Review term "diameter" making sure students know the definition. This problem also gives instructor an opportunity to use the problem solving process from Unit 1 – Introduction to Manufacturing Math Additional problems can be found in: *Mathematics for Machine Technology*, pp. 12-13, problems 9 -13 *Practical Problems in Mathematics for*

	Sawing Bar Stock • A job calls for cutting bars of metal into "blanks" that can be machined at a later date. The dimensions for the part is $3\frac{13}{32} \times 1\frac{1}{2}$. Since the overall length of the finish part is $3\frac{13}{32}$, how long must the "blanks" be to begin the work? The saw blade is $\frac{1}{16}$" You need to leave $\frac{1}{8}$" of material to clean up saw cuts on each end. What would the overall length of the "blanks" need to be? Guided Practice: Give students different dimensions for the length with the same saw blade and clean up material for practice. • $4\frac{13}{16}$ • $8\frac{7}{32}$ Change the length of the "blanks". Give a saw width of $\frac{1}{8}$" and give clean up material as $\frac{3}{16}$". • $7\frac{5}{16}$ • $10\frac{1}{2}$	*Manufacturing,* pp. 18 – 21 This is an excellent opportunity to revisit the problem solving process with your students.

Subtracting Fractions and Mixed Numbers Subtraction Applications	Show students how to subtract fractions with common denominators and then give them problems to practice. If necessary, review building fractions to have common denominators. Show students how to subtract fractions with uncommon denominators and give them problems to practice. Show students how to subtract whole and mixed number and then give students problems to practice. Practical Examples: 1. Draw a picture of a tapered pin on the board. The large end of the pin is $2\frac{13}{16}$ - inch in diameter and the small end has $2\frac{5}{8}$ - inch diameter. Determine the taper by calculating the difference in diameters. 2. On a lathe, a $\frac{7}{64}$ inch cut is made from a $1\frac{1}{2}$ inch diameter stock. What is the finished diameter? Guided Practice for practical problems will best be done with actual diagrams. There are excellent example problems in *Mathematics for Machine Technology* on pp. 14-15.	With subtraction, setting up the problem correctly is important. It is important to remind students about the necessity of order with subtractions. Additional practice can be found in: *Mathematics for the Trades*, p. 109, section A mixed addition and subtraction problems and p. 116, section C, mixed practice of addition and subtraction of fractions Additional problems can be found in: *Mathematics for Machine Technology*, pp. 16-18. *Practical Problems in Mathematics for Manufacturing*, pp. 22 – 25.
Multiplication	Show students how to *multiply fractions*.	

Multiplication Applications	Show students how to multiply fractions where the use of cross cancellation is possible. Give students a variety of problems to practice. To multiply *mixed and whole numbers with fractions*, show students that the same process is used, but they must change mixed numbers to improper fractions or make a whole number into a fractions. Give students a variety of problems to practice. Example problems: 1. What is the volume of a rectangular box with the following interior dimensions: $11\frac{5}{8}$ inches long by $7\frac{3}{4}$ inches wide by $3\frac{1}{2}$ inches deep? 2. How long will it take to machine 25 taper pins if each pin takes $7\frac{1}{2}$ minutes? To replace stock in lathe, allow 1 minute per pin. Guided Practice This will come for the additional problems listed at the right. It is important for the instructor to move around the class room to answer questions and check for student understanding.	Additional Problems can be found in: *Mathematics for Machine Technology*, p. 21, 1 a-f; and p. 22 Multiplying Mixed numbers, a-f *Practical Problems in Mathematics for Manufacturing*, p. 26, a-e *Mathematics for the Trades*, p. 83, a-i This is a good time to begin discussion of volume of rectangle and the formula of LWH to determine if students already have this knowledge. Additional Problems can be found in: *Mathematics for Machine Technology*, p.23 *Practical Problems in Mathematics for Manufacturing*, pp. 41-43

Division Division Applications	Ask students what the inverse of multiplication is. Tell students knowing it is the inverse of multiplication is an important part of dividing fractions. Show students how to divide fractions, making sure they understand why changing the sign and using the inverse or reciprocal of the second fraction is important. Now show students how to divide mixed numbers and fractions Examples: 1. The boring mill's feed is set for $\frac{1}{32}$ inch. How many revolutions are needed to advance the tool $3\frac{1}{16}$ inches? 2. How many threads are needed for the threaded section of a pipe that is $2\frac{1}{2}$ inches long, if the pitch of the tread is $\frac{1}{16}$ inch? Guided Practice This will come for the additional problems listed at the right. It is important for the instructor to move around the classroom to answer questions and check for student understanding.	With division, setting up the problem correctly is important. Students often reverse the divisor and the dividend. It is important to remind students about the necessity of order with division. Additional problems can be found in: *Mathematics for the Trades,* p. 92, problems 1 - 24 Additional problems can be found in: *Mathematics for Machine Technology*, pp. 33-35 *Practical Problems in Mathematics for Manufacturing,* pp. 29-31, problems 1-12
Order of Operations with Fractions	Tell students that in many cases they will have more than one operation using fractions to complete.	

	Ask students what they would do with a problem like: $\frac{3}{5} - \frac{1}{15} * \frac{10}{13}$ If students have problems, review basics of PEMDAS Try another problem: $\frac{1}{7} * \frac{5}{6} + \frac{5}{3} \div 1\frac{1}{6}$ Guided Practice: 1. $\left(\frac{1}{4}\right)^2 \div \frac{3}{4}$ 2. $\frac{5}{6} * \frac{1}{2} + \frac{2}{3} \div \frac{4}{3}$ 3. $\frac{6}{7} - \frac{4}{7} * \frac{1}{3}$ Walk around and work with students checking for understanding. This is a good opportunity for instructor to make sure students know how to correctly enter information into his/her own calculator. Tell students they will often be working with more than one operation with fractions. Give a few examples like the problems listed to the right.	Be sure to work out problems showing all steps including expanding any powers. Additional problems can be found in: *Mathematics for Machine Technology*, p 32 problems a-j Additional Problems can be found in: *Practical Problems in Mathematics for*

	Walk around and work with students checking for understanding.	*Manufacturing*, Unit 9, pp. 32-34
Tips for Working with Fractions	Remind students that fractions have many steps but often the error in accuracy is not lack of understanding but simple calculation error or copying the problem incorrectly. Here are a few tips for working with fractions. 1. Take your time. Do not rush just to finish the problem. Do your work carefully. 2. Focus on the problem. If you find your mind wandering, refocus or take a break. A wandering mind can lead to silly mistakes. 3. Always double check your problem to make sure you copied it correctly and things are put in the correct order. 4. Check your work from step to step. (A good reason to show all the steps on your work!) 5. Always check your solution to see if it makes sense – especially with word problems. 6. Always practice, practice, practice. Seeing the teacher do it once or twice on the board does not make you an expert. Many errors are simply due to lack of practice.	
Unity Fraction/Conversion	Converting between different units of measurement can often be daunting for many students. Students are often confused whether to multiply or divide. Although there is a chart that will give the conversions, one easy way to accomplish this with commonly used measurements is with the use of unity fractions. A unity fraction is simply amounts of two different units of measure that are the same. For example, 2 pints is the same as 1 quart.	Once students begin to see this relationship they can make conversions with any unit fractions. They do need to know the unit relationships. For Technical Math at COCC this is a skill that students have much trouble with, so being exposed to it earlier in an applied course will assist in their later success. There are additional examples of this

	Tell students we can write this as $\frac{1\,qt}{2\,pt}$ or $\frac{2\,pt}{1\,pt}$ since both of these are equal to 1 qt. or 1 If we wanted to find how many pints were in 7 qt of oil, we can use a unity fraction to calculate our results. Write the unit to be converted as a fraction, using 1 as the denominator $\frac{7qt}{1}$ Next, multiply this by a unity fraction so the quart's units cancel out. $\frac{7\,qt}{1} * \frac{2\,pt}{1\,qt}$ Finally, cancel quart units and multiply across: $\frac{7\,\cancel{qt}}{1} * \frac{2\,pt}{1\,\cancel{qt}} = \frac{7 * 2\,pt}{1} = \frac{14\,pt}{1}$ Your solution is 14 pints in 7 quarts. Show students an example like going from 36 pints to quarts. Step 1 $\frac{36\,pt}{1}$	process in: Mathematics for Machine Technology, pp. 125-126

Step 2

$$\frac{36\,pt}{1} * \frac{1\,qt}{2\,pt}$$

Step 3

$$\frac{36\,\cancel{pt}}{1} * \frac{1\,qt}{2\,\cancel{pt}} = \frac{36 * 1\,qt}{2} = \frac{36}{2} = 18\,qt$$

Now pose this question to students and help them work through it.

Pints to gallons

We need 500 pints of fluid for a particular repetitive job done in a shop. Since buying in bulk is so much cheaper, how many gallons need to be purchased?

Tell students they don't know how many pints are in a gallon, but they do know that there are 2 pints to a quart and 4 quarts to a gallon.

Step 1

$$\frac{500\,pt}{1}$$

Step 2 – We know both relationships

$$\frac{1\,pt}{2\,pt}\ or\ \frac{2\,pt}{1\,qt}$$

	and $\frac{1\,gal}{4\,qt}\ or\ \frac{4\,qt}{1\,gal}$ Step 3 – Be sure to set up this problems so that the pints and then the quarts will cancel out $\frac{500\,pt}{1} * \frac{1\,qt}{2\,pt} * \frac{1\,gal}{4\,qt}$ $\frac{500\,\cancel{pt}}{1} * \frac{1\,\cancel{qt}}{2\,\cancel{pt}} * \frac{1\,gal}{4\,\cancel{qt}}$ $\frac{500 * 1 * 1\,gal}{1 * 2 * 4} = \frac{500 * 1gal}{8} = 62.5\,gal$ Solution: 62.5 gallons or 63 gallons since you probably cannot order ½ gallons **Inches to miles** Change 21,750 inches to miles Decide what unity fractions you would need to get from inches to miles. $\frac{12\,in}{1\,foot}\ or\ \frac{1\,foot}{12\,inches}$	Students may want to go from feet to yards

	$\frac{1\ mile}{5280\ feet}$ or $\frac{5280\ feet}{1\ mile}$ Step 1 – $\frac{21{,}750}{1}$ Step 2 – set up the units so feet and inches will cancel out $\frac{21{,}750\ in}{1} * \frac{1\ ft}{12\ in} * \frac{1\ mile}{5280\ ft}$ $\frac{21{,}750\ \cancel{in}}{1} * \frac{1\ \cancel{ft}}{12\ \cancel{in}} * \frac{1\ mile}{5280\ \cancel{ft}}$ $\frac{21{,}750 * 1 * 1\ mile}{12 * 5280}$ $\frac{21{,}750}{63{,}360} = 0.34\ miles$ **Fpm to Ips** Demonstrate how to set up the unity fraction. $\frac{1\ min}{60\ sec}$ or $\frac{60\ sec}{1\ min}$	and then to miles, or they might go from inches to yards and then miles. Any of these should work. This will be helpful for students calculating speeds in machine shop

$$\frac{1\ ft}{12\ in}\ or\ \frac{12\ in}{1\ ft}$$

Step 1:

$$\frac{250\ ft}{1\ min}$$

Step 2:

$$\frac{250\ ft}{1\ min} * \frac{1\ min}{60\ sec} * \frac{12\ in}{1\ ft}$$

Step 3:

$$\frac{250\ \cancel{ft}}{1\ \cancel{min}} * \frac{1\ \cancel{min}}{60\ sec} * \frac{12\ in}{1\ \cancel{ft}}$$

$$\frac{250 * 1 * 12\ in}{1 * 60\ sec * 1}$$

$$\frac{3000\ in}{60\ sec}$$

$$\frac{50\ in}{1\ sec}$$

$$50\ ips$$

Guided practice:

1. 20 quarts to liters
2. 17 miles to kilometers
3. Changes 8.5 gallons to pints
4. Change 80 fpm to ips

	5. Convert 6.9 km/L to mpg	

This workforce solution was funded by a grant awarded by the US Department of Labor's Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the US Department of Labor. The Department of Labor makes no guarantees, warranties or assurances of any kind, express or implied, with respect to such information, including any information on linked sites and including, but not limited to, accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability or ownership.

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CASE is a WIA Title I- financially assisted program and is therefore an equal opportunity employer/program which provides auxiliary aids and services upon request to individuals with disabilities by calling 711 or 800.648.3458 TTY.

Unit 3: Decimals

Purpose of this unit is to introduce and review decimal numbers as they apply to students beginning manufacturing skills. Decimals are the preferred method of computation in the manufacturing industry, so students need to develop strong skills working with these numbers.

Student Objectives

Demonstrate accuracy in manipulating decimals including skills like reading, writing, rounding, adding, subtracting, multiplying and dividing while:

- Using micrometers
- Using calipers
- Using Vernier scales
- Calculating tolerances
- Changing fractions on blueprint measurements to all decimal measurements

Topic	Activity	Notes
Warm Up	Ask students where they use decimals in everyday life. Then ask students where they think decimal skills might be important in the manufacturing industry? Tell students that today they are going to start learning decimal basics and then explore some different applications to the manufacturing industry.	Answers might include activities involving money, cooking, measuring things *Depending on students' knowledge of the industry, they may or may not be able to come up with items in the student objectives. Prod students for as many ideas as possible.*
Decimal Numbers : What are they and why you need to understand them	Tell students that decimals are based on powers of 10. Show students what this means with wholes numbers by	

Reading Decimal Numbers	showing place values 10 through 1,000,000 Show students notations – like 10^3 = 10*10*10 Do a few more examples making sure students get this concept Tell students that before they can use decimals effectively, they need to understand how to read and write them correctly. Begin with reading decimal digits. Write a number on the board like 8,765,423 Go over the place values of each digit and what it means. Ask – what place is the 3 in? (ones) or 3 * 1 = 3 The 2? (tens) or 2 * 10 = 20 The 4? (hundreds) or 4 * 100 = 400 The 5?(thousands) or 5 * 1000 = 5000 The 6?(ten-thousand) or 6 * 10,000 = 60, 000 The 7? (hundred-thousand) or 7 * 100,000 = 700,000 The 8? (millions) or 8 * 1,000,000 = 8,000,000 Ask students if they notice a pattern in the place values. Show students that: 8,000,000 + 700,000 + 60,000 + 5,000 + 400 + 20 + 3 = 8,765,423 Tell students that all whole numbers have a decimal point at the end, but we don't use them when dealing just with whole numbers since it would be messy and cumbersome. EX: 1. + 2. +7. +10.	As you do this activity, write the place above each number. If a student does not understand this material, you may have to go back and review and have them review pp. 4-6 of *Mathematics for the Trades* or any similar materials that would help student with whole number place values.

<table>
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<td>Add a decimal point to the 8,765,423. Then write in several decimal digits up to the millionths place.

8,765,423. 320589
Ask students if they know the place values of these digits

0.320589
Remind students that they are still working with powers of 10, but now the numbers will get smaller rather than larger since

The 3 is in the tenths place or $(3*10^{-1}) = 0.3$
The 2 is in the hundredths place or $(2*10^{-2}) = 0.02$
The 0 is in the thousandths place or $(0*10^{-3}) = 0.000$
The 5 is in the ten-thousandths place or $(5*10^{-4}) = 0.0005$
The 8 is in the hundred-thousandths place or $(8*10^{-5}) = 0.00008$
The 9 is in the millionths place or $(9*10^{-6}) = 0.000009$

Ask students what they notice about the pattern of the place values.

Show students that:
0.000009 + 0.00008 + 0.0005 + 0.000 + 0.02 + 0.3 = 0.320589

Tell students each place represents a power of 10.

Model how to read this number –
Three hundred twenty thousand, five hundred eighty-nine millionths</td>
<td>Give students time to name places. Make sure they are accurate. If they don't know, go over each one.

Students will often ask about the zero to the right of the decimal point. In the English system, it is not required, but metrics do require it for proper notation. Fields like nursing do require it to prevent miscalculation of medication amounts.

This exercise is also a good opportunity to go over students' use of the calculator.</td>
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	Tell students to: • Read the number • Say the place of the last digit Tell students that this is a very small number and they probably won't be dealing with numbers this small in the manufacturing industry Model reading additional decimal numbers: 1. 0 .375 (three-hundred seventy-five thousands) because 5 is in the thousandths place 2. 0.72 (seventy-two hundredths) because 2 is in the hundredths place 3. 0.9 (nine tenths) because 9 is in the tenths place Tell students that when a certain number combines whole number and decimal fractions, the decimal point is read as AND not POINT. Model reading several more decimal numbers 1. 5.75 (five AND seventy-five hundredths) 2. 745.932 (seven hundred forty-five AND nine hundred thirty-two thousandths 3. 10.5 (ten AND five tenths) Guided Practice Have students work in pairs to say the following numbers. 1. 75.38	Students will probably resist saying these numbers correctly; however, it is important for them to understand place values and use decimals to *communicate in the workplace and with customers.* Remind students that being able to read decimals correctly will also help them to write and round them as well.

	2. 0.375 3. 110.201 4. 0.8912 5. 301.0001 Walk around, listen to students, and ask questions to check for understanding	
Writing Decimal Numbers	Tell students that they have learned to read decimals, so the next step will be to write them. Ask students a couple of numbers and see if they can write them correctly. Say: 1. Seventy-five thousandths (0.075) 2. Six and seven tenths (6.7) 3. Two hundred seventy-four ten-thousandths (0.0274) 4. Two hundred and seventy-four ten-thousandths (200.0074) 5. Nine hundred and one hundred-thousandths (900.00001)	Additional Practice for reading and writing decimals can be found in: *Mathematics for Machine Technology*, pp. 44-45, problems 4-34. Mathematics for the Trades, p 131, problems set A, 1-20

Rounding Decimal Numbers	Tell students that rounding decimals will be important for correct accuracy of their work in the manufacturing industry. Depending on the accuracy for certain jobs, some shop applications may need a number rounded to the nearest hundredth where as other applications like the manufacture of auto engine parts require a closer accuracy like thousandths or ten-thousandths. Whatever the application, correctly reading, writing, and rounding decimals will be important to your job. Tell students to round a decimal, 1. Identify the place you are going to round to and draw a line underneath it 2. Look to the right of that number. It may be helpful to circle the number while you are learning. a. If the number to the right is less than 5, drop all the digits to the right and the underlined number stays the same b. If the number to the right is 5 or greater, drop the numbers to the right and round up the under lined number to the next digit. Model the following examples for students: Round 0.65483 to the nearest thousandth 1. Identify and underline the number in the thousandths place. (4) 2. Look to the right. The number to the right is an 8, so you would increase the 4 to a 5. You drop all the digits	

	to the right and your final answer would be 0.655 Round 2.8347 to the nearest hundredth 1. Identify and underline the number in the hundredths place (3) 2. Look to the right. The number to the right is a 4, so the 3 would stay the same. All the numbers to the right will be dropped and your final answer is 2.83 Guided Practice **Round the following decimals as indicated.** Round to the nearest tenth: 1. 0.989 ________________ 2. 15.48 _________________ Round to the nearest hundredth: 3. 0.4926 _________________ 4. 0.0999 _________________ Round to the nearest thousandth: 5. 0.249987________________ 6. 0.771289 _______________	Rounding is an ongoing activity for most students. It is important for the instructor to quiz students often when completing different types of problems. Most decimal fractions used in COCC MFG course are rounded to 1000ths. It is important for students to understand it is ok to add zeros to the right to change to thousandths. For example 0.3 = 0.300; the dimensional is the same but the units of measure are different. Adding the "00" in

	7. 34.26 ________________	this case may make computation easier. Additional Practice can be found in: *Mathematics for Machine Technology*, p. 48
Changing between Decimals and Fractions	Another necessary skill for students to have is to switch between fractions and decimals. Tell students' that often they will find some fraction measurements on blueprint. It is a good idea for students to go over the blue print and change all fraction measurements to decimal. To change a fraction to a decimal, you need to divide the numerator by the denominator $\frac{1}{4}$ $1 \div 4$ 0.25 $\therefore \frac{1}{4} = 0.25$	It will be helpful for students to have a basic understanding of reading and dividing decimals before attempting to teach this section. Most calculators have this function to change between fractions and decimals, but it is important for students to understand the concept of what is happening to the numbers first. Manipulating between fractions and decimals also gives students a better understanding of benchmark fractions, decimals and percent and how they all can represent the same number such as $\frac{1}{4} = 0.25 = 25\%$ Tell students that to change a fraction or decimal to a percent, you simply need to multiply by 100 since percents are all based on 100.

	Try several more examples like: $\frac{1}{2}$, $\frac{9}{16}$, $\frac{3}{8}$ Guided Practice 1. $\frac{11}{64}$ 2. $\frac{5}{16}$ 3. $\frac{7}{32}$ 4. $\frac{1}{8}$ Now ask students how they would change a decimal to a fraction. Ask students if they remember how to read decimal digits. Show students that if they can read a decimal number they can write it as a fraction. Write 0.75 on the board	Additional Practice: *Mathematics for Machine Technology*, p. 48, problems 11-23.

	Ask students how to say this number (correctly!) Say *seventy-five hundredths* Show students how to write this as a fraction $\frac{75}{100}$ Ask students if they know what to do next. Reduce it: $\frac{75}{100}$ $\frac{75}{100} = \frac{\cancel{25} * 3}{\cancel{25} * 4} = \frac{3}{4}$ Try another 0.375 Say *three hundred and seventy-five thousandths* Show students how to write it	

Application: Reading a Steel Rule in Thousandths and Fiftieths Scales	$\frac{375}{1000}$ Ask students what they would do next. Reduce it: $\frac{375}{1000} = \frac{\cancel{5} * \cancel{5} * \cancel{5} * 3}{\cancel{5} * \cancel{5} * \cancel{5} * 8} = \frac{3}{8}$ Guided practice: 1. 0.625 2. 0.9375 3. 0.21875 4. 0.5625 5. 0.0625 *Tell students that there is a decimal/fraction equivalency chart, which can be found on the internet or is sometimes located in the classroom. However, if they learn their own benchmark fractions (that they use most often) they will not have to look them up.* Review 16^{th} or similar scale on overhead or document camera Show students $50^{th}/100^{th}$ steel rule and go over the two different scales. Tell students that decimal rules are used for fractional	Additional Practice can be found in: *Mathematics for Machine Technology*, p. 49. Problems 26-46 Students need to have actual $50^{th}/100^{th}$ steel rules or good quality pictures for this activity

	dimensions smaller that $\frac{1}{64}$. Using document camera, point out a fraction on the 100th scale. Ask students to read/write it as a fraction. Then ask students to read it as a decimal fraction. Example : $$\frac{37}{100} = 0.37$$ $\frac{7}{20} = 0.35$ Discuss both examples with the class Move on to the 50th scale. Tell students that $\frac{1}{50} = 0.02$ Point out the fraction $\frac{37}{50}$ Tell students to give the answer in decimal form. Ask students how they found the answer. Point out a few more examples and check that students understand the process.	Since there are two ways to find this answer it will be interesting for the instructor to find out how students formed their answers and see which big concepts they used – building fractions (like solving proportion or division of numerator by denominator). Additional Problems can be found in: Mathematics for Machine Technology, pp. 155-156; problems 5-7
Changing Decimals to Nearest Fraction with Specified Denominator	Explain to students that depending on the application, they may need to convert decimal measurements on a drawing to fraction with a specific denominator.	

	Change 0.558 in to the nearest 64th of an inch. $0.553 * \frac{64}{64}$ $\frac{0.553\ in * 64}{64}$ $\frac{35.392}{64}\ in$ Round to the nearest 64th of an inch by rounding the numerator to the nearest whole number. $\approx \frac{35}{64}$ Since there is an obvious error due to rounding that error between 0.553 and $\frac{35}{64}$ can be calculated as follows: $\frac{35}{64}\ in$ and $\frac{35.392}{64}\ in$ $\frac{35.392 - 35}{64}$ $\frac{.392}{64}$ $0.006125\ in$	

	Error is usually rounded to nearest ten-thousandth so error would be 0.0061 inch.	
Adding and Subtracting Decimal Fractions Practical Applications	Show students how to add and subtract decimal fractions with and without a calculator, telling students this is an important skill to have since it is often quicker to do it on paper. Working with tolerances • Explain what is meant by tolerance in a measurement compared to the dimensions of measurement • Go over unspecified tolerances for 2 place and 3 place decimals as well as fractional tolerance • Explain unilateral and bilateral tolerance • Show students how to find upper and lower limits of bilateral tolerances Example: Unless otherwise specified, tolerances are as follows: o 2-PL DEC IN. (.XX) $\pm .010$ o 3-PL DEC IN. (.XXX) $\pm .005$ o Fractional $\pm \frac{1}{64}$ A certain dimension should be a half-inch which can be written: $\frac{1}{2}$ .50 .500 Find the upper and lower limit of each of the measurements above: Upper limit = $\frac{1}{2} + \frac{1}{64} = \frac{33}{64}$	If students have not taken a Blueprint reading class, the instructor may have to assist students with things like the Title Block and how to read the tolerances Point out to students that even though we began with a the same dimension in each exercise, the tolerance is much closer in a 3-decimal dimension than a fractional or 2-dimensional measurement Machinists generally think of $\pm\frac{1}{64}$ as $\pm .015$ because of accuracy and rounding.

	Lower limit = $\frac{1}{2} - \frac{1}{64} = \frac{31}{64}$ Ask students if a machined part measured $\frac{29}{64}$ would it still be within tolerance. Find the upper and lower limits of .50 Upper limit = .500 + .010 = .510 Lower Limit = .500 - .010 = .490 Find the upper and lower limits of .500 Upper limit = .500 + .005 = .505 Lower limit = .500 - .005 = .495 Guided Practice: Give students following dimensions and have them find upper and lower limits. You can use tolerances listed above in the example. 1. .570 2. .845 3. .434 Micrometer • Explain what micrometer is used for (good time to explain difference between accuracy of measurement and precision instrument) • Using document camera, go over parts of mike. • Demonstrate how to hold micrometer and take a measurement. Talk about "feel" of correct adjustment	Practice Problems: *Mathematics for Machine Technology*, pp. 145-149. A class set of 0-1" mikes is ideal for teaching students. Be sure to have examples of 1-2", 2-3" so students understand. Also mikes with specific applications are helpful so students understand that the scale is the same.

	of mike to take measurement. (Remind student this is a precision instrument and not a c-clamp) • Give students the opportunity to practice taking measurements on specific items you have pre-measured in the classroom • Walk around and check for understanding. If students are having trouble with the "feel" of the measurement this is an excellent opportunity to help them. Micrometer with Vernier Scale • Explain the addition of the Vernier scale to students and why it's precision is important to their work • Show students how to read the scale • Show students how to include this reading in their calculation Calipers	Only Standard (English) micrometers are covered here. Metrics are covered in the metric unit. These can be presented at the same time; however, if students are really new to these tools, some separation of introduction is often helpful. Practice Problems can be found in: *Mathematics for Machine Technology*, pp. 169-170, problems 1-32 A class set of micrometers with Vernier scales is ideal for introducing the scale to students. If Vernier mikes are not available in class sets, then bring several mikes for students to see and provide high quality handouts for students to work with. When showing students how to add the decimals using a Vernier scale, be sure to extend all decimal measurement to the ten-thousandths place. Additional practice can be found in: *Mathematics for Machine Technology*, pp. 170 - 172, problems 33-64

Working with Measurement Tools	• Explain what calipers are used for • Explain types of calipers (inside/outside) • Talk about precision of inside and outside calipers, explaining that outside calipers are not a precision instrument, but inside calipers can be fairly precise if used correctly • Demonstrate how to use the inside caliper to measure the diameter of a hole and then check the measurement with an outside micrometer Guided Practice Have students use inside calipers measure several different hole diameters set up by instructor. Next, have them use micrometers to check accuracy of the measurements with the caliper. Instructor should walk around to watch student progress, answer questions, and make sure students are using calipers and micrometers correctly. Decimal Inch Vernier Caliper • Explain what Vernier Caliper is used for using overhead projector with pictures or document camera, go over the parts of Vernier caliper. • Tell students there are Vernier calipers with different scales: a 25-division inch Vernier caliper and a 50-inch Vernier caliper. • Demonstrate how take several measurements with both scales. Talk about "feel" of correct adjustment of Vernier caliper to take measurement.	Bring inside and outside calipers to class. Class sets would be ideal so students can practice measuring with inside calipers and checking the results with micrometers. It is important for students to once again get the correct "feel" of the instrument. A class set of Vernier calipers is ideal for this activity. If handouts or pictures in books are used for student practice, be sure to have Vernier calipers for students to see in the classroom.

	Guided Practice • Give students the opportunity to practice taking measurements on specific items you have pre-measured in the classroom. • Walk around and check for understanding. If students are having trouble with the "feel" of the measurement this is an excellent opportunity to help them. Decimal Inch Vernier Height Gage • Tell students purposes for using height gage • Show students different parts • Demonstrate how to take a measurement with a height gage.	Additional practice can be found in: *Mathematics for Machine Technology*, pp. 162-164 Additional practice can be found in: *Mathematics for Machine Technology*, p. 165 Another application for measuring instruments is Gage Blocks – both Standard and Metric. Problems can be found in: Mathematics for Machine Technology, pp. 174-176.
Multiplying Decimals Multiplying Applications Dividing Decimals	Show students how to multiply decimal. Calculating circumference of pitch circle Finding area of rectangles and other polygons Calculation weight Working with percent numbers Working with money to find total cost Working with formulas Show students how to divide decimals.	Multiplication and division will be included in other applications. It is good for students to have a basic understanding before working with things like geometry formulas.

Division Applications	Finding the mean (average) of a group of parts Statistical analysis in quality control (See that unit of curriculum for examples) Calculation of costs per unit Working with formulas	Tell students, when rounding a division problem, it is important to go one space beyond the point to which you need to round. For example, if you want to give your final answer in thousandths, you need to divide out to the 10,000ths place.

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